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GRUMMAN AIRCRAFT ENGINEERING CORPORATION

Bethpage, L. I., N. Y.

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This Specification supersedes LSP-330-2B dated 8-10-65.

SPECIFICATION

No. LSP-330-2C

Date: 1-31-66

CLASSIFICATION CHANGE

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Scientific and Technical Information Facility

SECTIONS 1, 2, 3, AND 4

ENVIRONMENTAL CONTROL SUBSYSTEM

DESIGN CONTROL SPECIFICATION FOR (U)

Contract No. NAS 9-1100

Exhibit E; para. 4.2

Line Item No. 3

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"WARNING: This material contains information affecting the national defense of the United [redacted] and the transmissi[redacted] in any manner to [redacted] person is prohibit[redacted]

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Grumman LEM

ENG 660.1 6-63

SPECIFICATION

Spec. No. LSP-330-2C

Date: 1-31-66

Page: A

Rev.	Date	REVISION DESCRIPTION
A	8-2-63	All changes negotiated with the vendor.
B	8-10-65	Program redefinition in addition to revision of configuration of Sections 1, 2, 3 and 4.
C	1-31-66	Revised to reflect Amendments 1 through 5.

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SECTIONS 1, 2, 3, AND 4

ENVIRONMENTAL CONTROL SUBSYSTEM

DESIGN CONTROL SPECIFICATION FOR (U)

1 SCOPE

1.1 Scope. - This specification establishes the requirements for the following sections of the Environmental Control Subsystem (ECS), for use in the Lunar Excursion Module (LEM) of the Apollo Spacecraft:

1 - Atmospheric Revitalization Section

2 - Oxygen Supply and Cabin Pressure Control Section

3 - Heat Transport Section

4 - Water Management Section

2 APPLICABLE DOCUMENTS

2.1 Government Documents. - Unless otherwise specified, the following Government documents of the issue in effect on January 14, 1963, form a part of this specification to the extent specified herein:

SPECIFICATIONS

NASA

MSFC-PROC-158A	Procedures for Soldering of Electrical Connections (High Reliability)	4-12-64
MSC-ASPO-S-5B with Supplement	Soldering Specification Supplement	2-10-64 5-18-64

2.1 (Continued)

Military

MIL-O-27210	Oxygen, Aviator's Breathing, Liquid and Gas
MIL-W-16878/4A	Wire Electrical, Type E, 200 Degrees C. and 260 Degrees C., 600 Volts, Insulated, High Temperatures, Navy

STANDARDS

Military

MIL-STD-202C	Test Methods for Electronic and Electrical Component Parts
MIL-STD-681	Identification Coding and Application of Hookup and Lead Wire
MIL-STD-704	Electrical Power, Aircraft, Characteristics and Utilization of
MIL-STD-810	Environmental Test Methods for Aerospace and Ground Equipment

2.2 Grumman Documents. - The following Grumman documents of the date of issue shown form a part of this specification to the extent specified herein:

SPECIFICATIONS

Number	Title	Date
LSP-14-001	Identification Markings, General Specification for	12-10-63
LSP-14-007	Identification and Traceability Requirements for LEM Program Vendors	2-1-65

2.2 (Continued)

Number	Title	Date
LSP-14-009 with Amendments 1, 2, 3, and 4	Preservation, Packaging and Packing, General Specification for	4-22-65
LSP-14-0011 with Amendment 1	Surface Cleanliness Levels, General Specification for	6-14-65
LSM-14-6001	Ethylene Glycol-Water Solution	9-13-65
LSP-350-602A with Amendments 1, 2 and 3	Indicators, Elapsed Time, Design Control Specification for	3-23-65
LSP-390-001	Bonding, Electrical, General Specification for	7-9-63
LSP-390-8A with Amendment 1	Connectors, Miniature Circular Electrical Power Subsystem, Design Control Specification for	7-14-65
LSP-530-001 with Amendment 1	Electromagnetic Interference Control Requirements, General Specification for	9-16-63

DRAWINGS

LSC330-101 (latest revision)	Heat Exchanger, Environmental Control, Cabin, Specification Control Drawing for
LSC330-102 (latest revision)	Fan, Environmental Control, Cabin, Specification Control Drawing for
LSC330-106 (latest revision)	Heat Exchanger, Environmental Control, Suit Circuit, Specification Control Drawing for
LSC330-107 (latest revision)	Water Evaporator, Environmental Control, Water, Specification Control Drawing for

2.2 (Continued)

LSC330-109 (latest revision)	Separator, Environmental Control, Water, Specification Control Drawing for
LSC330-110 (latest revision)	Canister, Environmental Control, CO_2 and Odor Removal, Specification Control Drawing for
LSC330-111 (latest revision)	Heat Exchanger, Environmental Control, Suit Circuit Regen., Specification Control Drawing for
LSC330-112 (latest revision)	Diverter Valve, Environmental Control, Suit Circuit, Specification Control Drawing for
LSC330-113 (latest revision)	Check Valve, Environmental Control, Cabin Gas Control, Specification Control Drawing for
LSC330-114 (latest revision)	Selector Valve, Environmental Control, Canister, Specification Control Drawing for
LSC330-115 (latest revision)	Selector Valve, Environmental Control, Water Separator, Specification Control Drawing for
LSC330-117 (latest revision)	Relief Valve, Environmental Control, Suit Circuit, Specification Control Drawing for
LSC330-118 (latest revision)	Fan, Environmental Control, Suit Circuit, Specification Control Drawing for
LSC330-119 (latest revision)	Check Valve, Environmental Control, Fan Backflow, Specification Control Drawing for
LSC330-122 (latest revision)	Cartridge, Environmental Control, CO_2 and Odor Removal, Specification Control Drawing for
LSC330-123 (latest revision)	Control, Environmental Control, Auto Fan Switch, Specification Control Drawing for

2.2 (Continued)

LSC330-124 (latest revision)	Sensor, Diff. Pressure, Environmental Control, Suit Circuit Fan, Specification Control Drawing for
LSC330-125 (latest revision)	Cartridge, Environmental Control, PLSS Refill, Specification Control Drawing for
LSC330-127 (latest revision)	Canister, Environmental Control, CO_2 and Odor Removal, Specification Control Drawing for
LSC330-128 (latest revision)	Crossover Valve, Environmental Control, Suit Supply, Specification Control Drawing for
LSC330-134 (latest revision)	Fan Condition, Environmental Control, Signal Control, Specification Control Drawing for
LSC330-150 (latest revision)	Sensor, CO_2 Partial Pressure, Environmental Control, Specification Control Drawing for
LSC330-190 (latest revision)	Suit Circuit Assembly, Environmental Control, Atmospheric Revitalization Section, Specification Control Drawing for
LSC330-191 (latest revision)	Cabin Air Recirculation Package, Environmental Control, Specification Control Drawing for
LSC330-201 (latest revision)	Pump, Environmental Control, Coolant, Specification Control Drawing for
LSC330-202 (latest revision)	Relief Valve, Environmental Control, Pump By-Pass, Specification Control Drawing for
LSC330-203 (latest revision)	Control Valve, Environmental Control, Cabin Temp., Specification Control Drawing for
LSC330-204 (latest revision)	Heat Exchanger, Environmental Control, Coolant Regenerative, Specification Control Drawing for

2.2 (Continued)

LSC330-208 (latest revision)	Control Valve, Environmental Control, Suit Temp., Specification Control Drawing for
LSC330-209 (latest revision)	Sublimator, Thermal Control, Environmental Control, Heat Transport, Specification Control Drawing for
LSC330-210 (latest revision)	Accumulator, Glycol, Environmental Control, Heat Transport, Specification Control Drawing for
LSC330-212 (latest revision)	Filter, Environmental Control, Coolant, Specification Control Drawing for
LSC330-213 (latest revision)	Check Valve, Environmental Control, Specification Control Drawing for
LSC330-214 (latest revision)	Quick Disconnect, Environmental Control, GSE (Male), Specification Control Drawing for
LSC330-217 (latest revision)	Control Switch, Environmental Control, Auto. Pump, Specification Control Drawing for
LSC330-218 (latest revision)	Pressure Sensor, Environmental Control, Pump Diff., Specification Control Drawing for
LSC330-221 (latest revision)	Freon Boiler, Environmental Control, Heat Transport, Specification Control Drawing for
LSC330-222 (latest revision)	Filter, Glycol, Environmental Control, Specification Control Drawing for
LSC330-223 (latest revision)	Quick Disconnect, Environmental Control, GSE (Female), Specification Control Drawing for
LSC330-224 (latest revision)	Water Evaporator, Environmental Control, Coolant, Redundant/Second Primary, Specification Control Drawing for
LSC330-290 (latest revision)	Recirculation Assembly, Environmental Control, Coolant, Specification Control Drawing for

2.2 (Continued)

LSC330-303 (latest revision)	Relief Valve, Environmental Control, O_2 Pressure, Specification Control Drawing for
LSC330-304 (latest revision)	Shut-Off Valve, Environmental Control, Oxygen, Specification Control Drawing for
LSC330-305 (latest revision)	Check Valve, Environmental Control, Oxygen, Specification Control Drawing for
LSC330-306 (latest revision)	Demand Regulator, Environmental Control, Oxygen, Specification Control Drawing for
LSC330-307 (latest revision)	Dump Valve, Environmental Control, Cabin Press. & Relief, Specification Control Drawing for
LSC330-308 (latest revision)	Press. Switch, Environmental Control, Cabin, Specification Control Drawing for
LSC330-309 (latest revision)	Repress. and Emerg. Valve, Environmental Control, Cabin O_2, Specification Control Drawing for
LSC330-310 (latest revision)	Flow Limiter, Environmental Control, Suit Circuit O_2, Specification Control Drawing for
LSC330-312 (latest revision)	Disconnect, Environmental Control, PLSS O_2, Specification Control Drawing for
LSC330-313 (latest revision)	Check Valve, Environmental Control, Manual Override, Specification Control Drawing for
LSC330-314 (latest revision)	Filter, Orifice, Environmental Control, O_2, Specification Control Drawing for
LSC330-315 (latest revision)	Filter, Environmental Control, O_2, Specification Control Drawing for

2.2 (Continued)

LSC330-316 (latest revision)	Hose, Environmental Control, O_2, Specification Control Drawing for
LSC330-317 (latest revision)	Support and Cap, Environmental Control, Oxygen Disconnect, Specification Control Drawing for
LSC330-323 (latest revision)	Press. Switch, Environmental Control, Cabin, Specification Control Drawing for
LSC330-390 (latest revision)	Control Module, Environmental Control, Oxygen, Specification Control Drawing for
LSC330-391 (latest revision)	Hose Assembly, Environmental Control, Oxygen, Specification Control Drawing for
LSC330-401 (latest revision)	Check Valve, Environmental Control, Water, Specification Control Drawing for
LSC330-402 (latest revision)	Shutoff Valve, Environmental Control, Water, Specification Control Drawing for
LSC330-403 (latest revision)	Water Disconnect, Environmental Control, PLSS, Specification Control Drawing for
LSC330-404 (latest revision)	Tank, Environmental Control, Descent Stage, Water, Specification Control Drawing for
LSC330-406 (latest revision)	Feed Valve, Environmental Control, Evap. Water, Specification Control Drawing for
LSC330-409 (latest revision)	Tank, Environmental Control, Ascent Stage, Water, Specification Control Drawing for
LSC330-410 (latest revision)	Isolation Valve, Environmental Control, Water, Coolant, Specification Control Drawing for

2.2 (Continued)

LSC330-414 (latest revision)	Selector Valve, Environmental Control, Water Tank, Specification Control Drawing for
LSC330-415 (latest revision)	Pressure Regulator, Environmental Control, Water, Specification Control Drawing for
LSC330-416 (latest revision)	Hose, Environmental Control, Water, Specification Control Drawing for
LSC330-418 (latest revision)	Disconnect, Ground Servicing, Gas, Environmental Control, Specification Control Drawing for
LSC330-419 (latest revision)	Disconnect, Ground Servicing Water, Environmental Control, Specification Control Drawing for
LSC330-420 (latest revision)	Shutoff Valve, Environmental Control, Water, Specification Control Drawing for
LSC330-421 (latest revision)	Support and Cap, Environmental Control, Water Disconnect, Specification Control Drawing for
LSC330-490 (latest revision)	Control Module, Environmental Control, Water, Specification Control Drawing for
LSC330-492 (latest revision)	Check Valve Assembly, Environmental Control, Water, Specification Control Drawing for
LDW330-6000 (latest revision)	Schematic, Environmental Control Subsystem

BULLETIN

AMCA-BULL-300	Sound Testing at Air Moving Services	2-62

Engineering Data

LED-330-3	End-Item Effectivity and Instrumentation Data, LEM Engineering Data for	11-17-65

2.3 Availability of Documents. -

2.3.1 Government Documents. - Copies of Government documents may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D.C., 20402.

2.3.2 Grumman Documents. - Copies of this specification and other applicable Grumman documents may be obtained from LEM Program Data Management, Grumman Aircraft Engineering Corporation, Bethpage, Long Island, New York, 11714, Attention: Purchasing Department.

3 REQUIREMENTS

3.1 Materials and Processes. - In the selection of materials and processes, fulfillment of major design requirements shall be the prime consideration. Materials and processes selected shall be subject to Grumman approval.

(a) In addition, processing equipment and certification of processing personnel shall be subject to Grumman approval.

(b) When temporary substitutions are made, drawings shall note the applicable government specification of the alternate material when applying for Grumman approval.

3.1.1 Material Degradation Products. - A material shall not, as a result of exposure to its service environment, evolve degradation products of such a nature or quantity that the operation of the LEM or its components will be impaired.

3.1.2 Crew Compartment Areas. - Materials selected for use in crew compartment areas shall not produce toxic or noxious environmental degradation products. In addition, these materials shall be capable of functioning in an atmosphere of pure (100%) oxygen before, during and after exposure to all environmental conditions without contributing to a potential fire or explosion hazard.

3.2 Design and Construction. -

3.2.1 Configuration. - The configuration of the ECS, Sections 1, 2, 3 and 4 shall be as shown in LDW330-6000.

3.2.2 Electrical System. -

3.2.2.1 Operating Voltages. - The ECS, excluding instrumentation, shall operate with input voltages in accordance with 3.2.2.1.1.

3.2.2.1.1 DC Power. - The dc power available will be 28 VDC, negative ground, with the following characteristics:

3.2.2.1.1.1 Steady-State Voltage Limits. - The steady-state voltage limits shall be 25 to 31.5 volts.

3.2.2.1.1.2 Low-Line Limits. - The low-line limits shall be 20 volts for periods not exceeding five (5) seconds.

3.2.2.1.1.3 Transient Voltage Limits. -

(a) Positive - Transient voltage limits shall be 78 volts for 10 microseconds at 10 pps repetition rate for a period of five (5) minutes.

(b) Negative - Transient voltage limits shall be 100 volts for 10 microseconds at 10 pps repetition rate for a period of five (5) minutes.

3.2.2.1.1.4 Ripple. - Per MIL-STD-704.

3.2.2.2 Electrical Power. - The power drawn from the LEM power source exclusive of that required by instrumentation (as defined in 3.2.7) shall not exceed the values shown in Table IX at 28 volts DC.

3.2.2.3 Electromagnetic Interference. - The system shall meet the requirements of Grumman Specification LSP-530-001 and as specified herein.

3.2.2.3.1 Suppressors. - The vendor shall design. quality and supply all EMI suppressors as shown in Table XI and LED-330-3.

3.2.2.3.2 Load Generated Noise. - The ECS equipment shall not cause a ripple voltage in excess of 0.5 volts peak from 20 cps to 15 kc. on the dc power lines when measured across an impedance of 0.5 ohms in series with a 20 microhenry inductor.

3.2.2.4 Grounding. - The DC negative shall not be connected to chassis ground. Filter capacitors used in EMI suppressors shall be capacitively coupled to the case.

3.2.2.5 Electrical Components. -

3.2.2.5.1 Protective Devices. - The ECS shall not incorporate fuses, circuit breakers, or other protective devices requiring replacement or resetting.

3.2.2.5.2 Motors. - Motors utilizing mechanical commutation or slip-rings shall not be used.

3.2.2.5.3 Solenoids. - All solenoids used in the ECS shall be of the latching type, except as approved by Grumman.

3.2.2.5.4 Switches. - The use and type of switches will be specified by Grumman as required.

3.2.2.5.5 Indicating Devices. - The use and type of indicating devices will be specified by Grumman as required.

3.2.2.6 Dielectric Strength. - Electrical items at the parts level, excluding instrumentation and power circuit EMI filters, shall withstand without electrical breakdown a dielectric voltage of 1500 volts rms, 60 cps, in accordance with MIL-STD-202, Method 301. For the above exceptions the values of 3.2.7.10 shall be used. Breakdown failure shall be defined as leakage current in excess of 500 microamps.

3.2.2.7 Insulation Resistance. - Electrical items at the parts level, excluding instrumentation and power circuit EMI filters, shall maintain a minimum insulation resistance of 5000 megohms when measured at 500 volts DC in accordance with MIL-STD-202, Method 302. For the above exceptions, the values of 3.2.7.12 shall be used.

3.2.2.8 Ignition Proof. - Electrical components or the operation of same, shall not be capable of igniting any explosive mixture existing in the cabin and shall not contribute to the generation of toxic, noxious flammable or explosive mixtures.

3.2.2.9 Fail-Safe Provisions. - Electrical or electrically operated components shall be designed so that any failure does not propagate sequentially, that is, the design shall be fail-safe.

3.2.2.10 Electrical Wiring. - The wiring used for the interconnection of electric or electrically operated equipment shall meet the functional and environmental requirements specified in MIL-W-16878/4.

3.2.2.10.1 Routing and Support. - Electrical wiring shall be properly supported and routed to:

(a) Provide accessibility for inspection and maintenance.

(b) Minimize the possibility of damage.

(c) Prevent chafing and provide protection when wires or cables are routed across protruding structural members, sharp edges, or hot spots.

(d) Provide separation of wires or cables from lines containing fuels and oxidizers.

(e) Provide a minimum bend radius of ten (10) times the outside diameter for all wires routed singly or in the build-up of pre-formed cables; provide a minimum bend radius of ten (10) times the outside diameter of the cable for all cables which are bent after forming.

(f) Minimize excessive slack.

(g) Effectively eliminate electromagnetic interference to the limits specified in Grumman Specification LSP-530-001.

(h) Secure wires and cables when routed through structural members.

(i) Prevent mechanical strain that would tend to break conductors and/or connections.

(j) Wires and cables shall be supported at suitable intervals to prevent excessive movement under all vibration conditions.

3.2.2.10.2 Junctions. - Wire and cable junctions shall be selected in the following order of preference.

(a) Crimp type terminals and splices.

(b) Soldered, brazed or welded junctions.

(c) Connectors.

3.2.2.10.3 Wiring Identification. - Wiring identification procedure shall be in accordance with MIL-STD-681. Any deviation from MIL-STD-681 shall require Grumman approval.

3.2.2.11 Electrical Bonding. - Electrical bonding shall be in accordance with Grumman Specification LSP-390-001.

3.2.2.12 Thermal Design. - A prime consideration in the design of all electrical and electrically operated devices shall be the thermal effect of a space vacuum on rated and overload characteristics of electrical devices.

3.2.2.13 Connectors. - Electrical connectors may be used where frequent disconnection is required subject to Grumman approval. If required connectors shall be selected in accordance with Grumman Specification LSP-390-8. Where items are too small for connectors they shall include electrical lead wires no less than three feet in length.

3.2.3 Vibration Design. - Equipment in the ECS shall be designed so as to eliminate inducing objectionable vibration levels. Rotating equipment shall be balanced such that the displacement of the equipment measured at the mounting location while the equipment is freely suspended and operated at normal loading and speed conditions shall not exceed the values listed below.

Rotational Speed rpm	Measured Vibration Inches DA
30,000 rpm	2×10^{-5}
25,000 rpm	2×10^{-5}
11,000 rpm	8×10^{-5}
500 rpm	1×10^{-4}

3.2.3 (Continued)

NOTE: The applied vibrational environment for launch and boost, translunar, descent and ascent phases of the mission consists of random excitation up to 2000 cps. The high acceleration density levels at low frequencies are presented for use in design analysis only since available test equipment is incapable of reproducing the complete spectrum. The test requirements include separate sinusoidal vibrations to account for this low frequency portion of the random spectrum as well as to determine the design adequacy in individual vibrational modes. See test requirements in 4.3 and Tables V-A and VI-A. (Qualification Test Conditions) for test procedures and times. Test requirements shall be considered as part of the vibration design. The vibration levels in the environmental tables are inputs from the LEM primary structure. The modifying effects of secondary structure (including LEM secondary structure) shall be considered in determining vibration loads for design analysis.

3.2.3.1 Vibration Amplification Factors. - The vibrational motion amplification factor on any portion of the equipment shall be limited to a maximum of 10 where not already limited to a lower value by other design requirements. This criteria shall be substantiated during development testing.

(a) Equipment and subassemblies including the basic chassis and/or mounting structure of equipment (such as brackets and shelves) shall be free of mechanical resonances below 60 cps.

(b) Piping, ducting and wiring runs shall be supported, so as to be free of mechanical resonances below 60 cps.

3.2.4 Acoustical Noise Level. - Acoustical noise levels generated by the ECS shall not exceed the values listed as measured at the ear level of crew members. To demonstrate this requirement, acoustical measurements shall be made on the noise generating components of the ECS when terminated by lines or chamber representative of the installation in the LEM. Sound testing shall be in accordance with AMCA-BULL-300.

3.2.4 (Continued)

20 to 75 cps	75 to 150 cps	150 to 300 cps	300 to 600 cps	600 to 1200 cps	1200 to 2400 cps
73 db	66 db	60 db	55 db	52 db	50 db

2400 to 4800 cps	4800 to 10,000 cps
48 db	47 db

NOTE: Decibels are referred to 0.0002 dynes/sq. cm.

3.2.5 Structural Design. -

3.2.5.1 General. - Environmental and load conditions shall be in accordance with Table I.

3.2.5.2 Design Load Envelopes. - Design load envelopes for all ground and operational conditions shall be established by superposition of rationally deduced critical loads and shall include cumulative effects as well as simultaneous loadings.

3.2.5.3 Pressurized Environment. - All equipment including that located within the pressurized cabin shall be designed to function without failure for a minimum of two days in a vacuum after non-operating exposure to vacuum for five (5) days. Heat Transport Section and Water Management Section items shall operate continuously for a minimum of seven (7) days in a vacuum.

3.2.5.4 Failures. - Section or component failures shall not propagate sequentially.

3.2.5.5 Ultimate Factors. - Table I contains actual environment and load conditions (no safety factors applied). Structural design, proof and ultimate factors shown in Table I-A shall be applied to limit values.

NOTE: The proof and ultimate factors of Table I-A shall be applied to self-generated structural limit loads of the ECS. Rational allowance shall be made and incorporated in all structural loads and stresses for stress concentrations, fatigue loadings, thermal stresses and dynamic response.

3.2.5.6 Radiation Environment. - Charged particle and electromagnetic radiation, present in cislunar space, originating from the Van Allen belts, solar flares and space background shall be considered in the design.

3.2.6 Thermal Design. -

3.2.6.1 General. - The ECS equipment shall be capable of satisfactory and reliable operation when exposed to the thermal conditions of Table I. The thermal design of the equipment shall be limited to the following categories:

(a) Forced Convection cooled equipment.

(b) Cold Plate cooled equipment.

For design purposes all ECS equipment shall be considered as thermally isolated from conduction from the spacecraft structure.

3.2.6.2 Forced Convection Cooled ECS Equipment. - Forced convection cooled equipment shall be capable of:

(a) Continuous operation in an external oxygen atmosphere or vacuum while being cooled by the working fluid.

(b) Continuous operation for all working fluid temperatures.

NOTES:

1. With the exception of the cabin and suit fans, when the ECS equipment is exposed to an external environment at 160°F, the external surface of the equipment shall not exceed a temperature of 160°F for all combinations of duty cycle and fluid temperatures. The external surfaces of the suit and cabin fans shall not exceed a temperature of 180°F for all combinations of duty cycles and cabin oxygen temperatures.

2. The cabin fan shall not be required to operate in a vacuum.

3.2.6.2.1 External Surface Characteristics. - The external surfaces of ECS equipment in the cabin shall have an infra-red emittance of less than 0.60. The external surfaces of ECS equipment in other areas shall have an infra-red emittance of less than 0.10.

3.2.6.3 Cold Plate Cooled ECS Equipment. - Cold plate cooled ECS equipment shall be capable of continuous operation in a vacuum or oxygen atmosphere while being cooled by a thermal control system in which the ECS equipment heat sink surface is conductively mounted on a coolant cooled plate capable of accepting all of the ECS equipment's waste heat. (The heat sink surface is that surface of the ECS equipment designed to reject the equipment's waste heat.) The ECS equipment shall be capable of continuous operation at any heat sink surface temperature within the range of 0°F to 130°F. When the ECS equipment is exposed to an external environment at 160°F, the equipment's external surfaces (other than the heat sink surface) shall not exceed a temperature of 160°F for all combinations of power dissipations and heat sink surface temperature.

3.2.6.3.1 Heat Sink Surface Design. - The size of the ECS equipment heat sink surface shall be sufficient to conduct all of the equipment's waste heat to the coolant and shall be based upon the equipment's power profile. Under steady state conditions, it shall provide at least one square foot of area for every 144 watts of waste heat.

3.2.6.3.2 Surface Finish. - The heat sink surface of the ECS equipment shall be smooth and free from protrusions of any type. It shall be flat to within 0.010 total indicator-reading and have a surface finish of less than 63 microinches.

3.2.6.3.3 External Surface Characteristics. - All external surfaces of the ECS equipment shall have an infra-red emittance of less than 0.1.

3.2.6.3.4 Internal Design. - The internal thermal packaging and design shall be based on the following criteria:

3.2.6.3.4 (Continued)

(a) Provision shall be made for maintaining the external surfaces of the ECS equipment in good thermal contact with the internal power dissipating components and the heat sink surface.

(b) The inside surfaces of the ECS equipment shall have an infra-red emittance of at least 0.90.

(c) The maximum temperature gradient between the heat sink surface and the internal components shall be limited to 30°F unless reliable operation with higher gradients can be demonstrated to the satisfaction of Grumman.

(d) Contact resistances in the thermal paths shall be avoided wherever possible. When unavoidable, they shall be filled with an appropriate material to minimize the gradients encountered.

(e) Within the limits of good circuit design, the location of the components shall be such that the heat input to the heat sink surface shall be as uniform as possible.

(f) The temperature and temperature gradients specified are the anticipated extremes that the ECS equipment will be expected to experience during the mission. All ECS equipment operation, performance and reliability requirements shall be met within these extremes.

3.2.7 Instrumentation. - Instrumentation to monitor the performance of the equipment during all phases of its test and operation (excluding that for automatic ECS control) shall be as shown in Table XI and delivered to Grumman in accordance with LED-330-3. All other instrumentation required for development and qualification testing are the vendor's own responsibility. The removal of an instrument (Table XI) from a base component shall not compromise the performance or reliability of that base component. The sensors and signal conditioning equipment selected for each application shall have an inherent reliability greater than the Environmental Control Subsystem. The instruments shall be compensated such that capability to perform the intended function is not degraded by the environmental conditions to which they are subjected.

3.2.7.1 Calibration. - All instrumentation shall be calibrated. Calibration procedures shall be subject to Grumman approval prior to use. Suitable standards, traceable to the National Bureau of Standards shall be used.

3.2.7.2 Electrical. - All instrumentation, wiring, and components shall meet the requirements set forth in 3.2.2, except for those sections where instrumentation is specifically excluded.

3.2.7.3 Excitation Voltage. - Excitation voltages and voltage levels shall be 28 $^{+4}_{-8}$ volts DC unregulated with transients as per 3.2.2.1.1.3. Excitation voltages for status lights circuitry shall be 5 volts DC.

3.2.7.4 Inaccessible Areas. - Location of sensors in inaccessible areas shall be avoided. If a sensor must be located in an inaccessible area, a redundant sensor shall also be installed unless specifically expected by Grumman.

3.2.7.5 R & D Measurements. - Grumman will determine the measurement requirements and responsibility for all R & D Measurements. This determination will be made for each vehicle as dictated by the flight development program. The vendor shall provide all the necessary pickup points, and if required, install those sensors determined by Grumman to be his responsibility.

3.2.7.6 Groups. - Instrumentation and provisions for instrumentation shall be provided as specified in LDW330-6000 and Table XI. The measurements specified shall be categorized into the following groups.

3.2.7.6.1 Group 1A. - Environmental characteristics for all measurements shall be provided. Pickup points shall be provided compatible with Grumman specified sensors.

3.2.7.6.2 Group II. - The vendor shall:

(a) Provide the pickup point

(b) select and purchase sensor

Sensor shall be selected from the selection list and must be Grumman approved.

3.2.7.6.3 Group III. - The vendor shall:

(a) Provide the pickup point

(b) Select, purchase and install sensor

(c) Select, purchase and install or design and install signal conditioners (if required). All signal conditioners shall require the approval of Grumman. The signal conditioners shall be located within the subsystem, or within the applicable subsystem assembly or equipment. In addition, signal conditioning circuits shall be so packaged and located as to facilitate their removal with minimized effect upon the subsystem and subsystem equipment.

3.2.7.7 Fail Safe. - Vendor instrumentation shall be designed so as not to cause damage or generate spurious failure signals to other instrumentation or vendor equipment.

3.2.7.8 Safety Wire. - All instrumentation equipment shall be secured with safety wire where applicable.

3.2.7.9 Electrical Connector. - Electrical connector information will be supplied by Grumman as required.

3.2.7.10 Dielectric Strength. - Instrumentation shall withstand without electrical breakdown a dielectric voltage of 200 volts peak to peak, 60 cps, in accordance with MIL-STD-202, Method 301. Breakdown failure shall be defined as leakage current in excess of 50 microamps.

3.2.7.11 Circuit Isolation. - Primary input power shall be isolated from the signal output by a minimum of 50 megohms at 50 volts DC.

3.2.7.12 Insulation Resistance. - Instrumentation shall maintain a minimum insulation resistance of 100 megohms at 100 volts DC in accordance with MIL-STD-202, Method 302.

3.2.8 Cleanliness. - The cleanliness of the ECS equipment shall be in accordance with Grumman Specification LSP-14-0011, paragraph 3.6.2.4.1.

3.2.9 Soldering. - Where hand soldering is used, all soldering shall be in accordance with MSFC-PROC-158 and MSC-ASPO-S-5 with supplement, except that all references to MSFC and MSC shall be interpreted to be Grumman.

3.3 Performance. -

3.3.1 General. - The ECS sections listed in 1.1 shall perform the functions and meet the requirements described in this specification when operated together as an integrated ECS or when operated singly with the effects of other ECS sections simulated.

3.3.2 Service Life. - The total service life of the ECS dynamic components shall be a minimum of 2500 hours with replacement of limited life items at 1250 hours unless otherwise specified herein. The service life for static components shall be 4000 hours.

3.3.2.1 Cycle Life. - Cycle life for each item shall be determined and specified as a requirement along with the service life.

3.4 Section Requirements. -

3.4.1 Atmosphere Revitalization Section. - The Atmosphere Revitalization section shall perform the following functions:

(a) Cool and ventilate the space suits worn by the crew.

(b) Maintain within prescribed limits the level of carbon dioxide in the atmosphere breathed by the crew.

(c) Remove odors and noxious gases from the atmosphere breathed by the crew.

(d) Remove foreign objects originating within or entering the section which are capable of causing malfunction of the ECS or impairment of crew performance.

3.4.1 (Continued)

(e) Condense and remove excess moisture from the section and cabin atmospheres.

(f) Provide control of the temperature of the gas delivered to the crew's space suits.

(g) Provide directional control of the flow of gas through the crew's space suits.

3.4.1.1 Configuration. - The Atmospheric Revitalization Section shall consist of the items shown in LDW330-6000.

3.4.1.2 Component Functions. -

3.4.1.2.1 Suit Circuit Heat Exchanger (LSC330-106). - The suit circuit heat exchanger shall, under normal conditions, reject all waste heat from the suit circuit to the Heat Transport Section coolant. The suit circuit heat exchanger shall be designed to reject the total metabolic heat loads of both crew members as given in Table II-A, all electrical and chemical reaction heat generated within the suit circuit and all heat transferred into the suit circuit from the cabin atmosphere.

3.4.1.2.2 Suit Circuit Water Evaporator (LSC330-107). - The suit circuit water evaporator shall provide for rejection of suit circuit waste heat when heat rejection by the suit circuit heat exchanger (LSC330-106) is inadequate. Evaporated water shall be discharged through a Grumman-supplied duct to the LEM ambient atmosphere environments specified in Table I. Pressure at the interface of the evaporator and the Grumman duct will not exceed 0.4 mm Hga. The suit circuit water evaporator shall be designed and/or provided with controls to preclude the possibility of malfunction due to freeze-ups in the evaporant or suit circuit gas flow paths.

3.4.1.2.3 Water Separators (LSC330-109). - Excess moisture condensed in the suit circuit heat exchanger (LSC330-106) or suit circuit water evaporator (LSC330-107) shall be removed from the suit circuit by gas-driven centrifugal water separators. Only one separator shall be

3.4.1.2.3 (Continued)

operated at a time. Each separator shall be capable of providing water removal at the maximum design rate and at sufficient pressure to be compatible with the Water Management Section.

3.4.1.2.4 Water Separator Selector Valve (LSC330-115). - A manually operated valve shall be provided for selecting the water separator (LSC330-109) to be operated.

3.4.1.2.5 Suit Circuit Regenerative Heat Exchanger (LSC330-111). - The suit circuit regenerative heat exchanger shall transfer heat from the Heat Transport Section coolant to the suit circuit gas stream and be so designed as to permit the crew members control of the temperature of the ventilating gas entering the space suits throughout the range specified in 3.4.1.3.3. The methods of effecting this control shall be as specified in 3.4.3.2.10.

3.4.1.2.6 Suit Circuit Diverter Valve (LSC330-112). - A valve shall be provided to allow the crew to pass the entire gas flow of the suit circuit downstream of the suit circuit relief valve (LSC330-117) into the cabin. This shall be done during open-face-plate operation so that the suit circuit shall handle sufficient cabin air to maintain the carbon dioxide level of the cabin within the limits prescribed in 3.4.1.3.4. The diverter valve shall be manually operated but shall include provision for automatic closure by signals initiated from the cabin pressure switch (LSC330-308 or -323) and/or the Oxygen Inflow Valves (LSC330-306).

3.4.1.2.7 Suit Circuit Relief Valve (LSC330-117). - A relief valve shall be provided to preclude over-pressurization of the space suit and suit circuit. This valve shall be aneroid operated in response to the suit circuit pressure. The valve shall be fully open with a suit circuit pressure of 4.4 psia or greater and fully closed whenever the suit circuit pressure is less than 4.1 psia. The valve shall include provisions for manual override (open or closed) by the crew in the event of malfunction.

3.4.1.2.8 Cabin Gas Return Check Valve (LSC330-113). - A check valve shall be installed in the duct returning cabin gas to the suit circuit to prevent loss of suit circuit gas in the event of cabin decompression.

3.4.1.2.8 (Continued)

The check valve shall have provisions to be manually overridden (open and closed) by the crew in the event of a malfunction. Provisions shall be made for attaching an inlet screen assembly or a ground support cap to be supplied by Grumman.

3.4.1.2.9 LEM Carbon Dioxide and Odor Removal Cartridge (LSC330-122). - The carbon dioxide level in the atmosphere measured at suit inlet shall be maintained within the limits prescribed in 3.4.1.3.4 by absorption in lithium hydroxide. Odors shall be removed from the atmosphere breathed by the crew by absorption in activated charcoal. The lithium hydroxide and activated charcoal shall be packaged together in replaceable cartridges each of which is adequate for 41 manhours of operation using average CO_2 production rate of 0.098 lbs. per manhour. The cartridges shall incorporate filtering provisions to prevent escape of lithium hydroxide and/or activated charcoal.

3.4.1.2.10 LEM Carbon Dioxide and Odor Removal Canister (LSC330-110). - The carbon dioxide and odor removal canister shall contain a single LEM carbon dioxide and odor removal cartridge (LSC330-122). The canister shall be designed for removal and replacement of used cartridges without impairing the integrity of the suit circuit in accordance with 3.4.1.3.1(c). A removable debris trap shall be provided as an integral part of the canister to prevent particular contaminants from entering the LEM carbon dioxide odor removal cartridge. The debris trap shall be replaceable prior to but not during flight. A relief valve shall be incorporated to permit flow to bypass the debris trap in the event it clogs. Means shall be incorporated to prevent any foreign matter from leaving the canister and entering the suit circuit.

3.4.1.2.11 Canister Selector Valve (LSC330-114). - The canister selector valve shall permit the crew to manually select for use either of the LEM carbon dioxide and odor removal canister (LSC330-110) or the PLSS carbon dioxide and odor removal canister (LSC330-127). The valve shall consist of two diverter-valves, one at the inlet and one at the outlet of the canisters linked together mechanically. The valve shall be mechanically linked to the canisters to preclude opening of the canister which is in use. The valves shall be sufficiently leak proof to permit replacement of carbon dioxide and odor removal cartridges (LSC330-122 and -127) with the cabin decompressed without degrading suit circuit pressure below the limit specified in 3.4.1.3.1(c).

3.4.1.2.12 Suit Circuit Fan (LSC330-118). - Parallel fans shall be provided for recirculation of gas through the suit circuit. Only one fan shall be operated at a time and each shall meet the recirculation performance specified in 3.4.1.3.2. The fans shall be capable of maintaining the pressure vessel integrity of the suit circuit in the event of any internal fan failure. The fans shall be designed to permit operation at sea level for checkout purposes. Provisions for such sea level operation shall be designed for minimum effect on the weight and operational reliability of the fans.

3.4.1.2.13 Fan Backflow Check Valve (LSC330-119). - Check valves shall be provided downstream of the suit circuit fans (LSC330-118) to prevent reverse flow through the inoperative fan from short-circuiting the operating fan.

3.4.1.2.14 Suit Circuit Assembly (LSC330-190). - The suit circuit assembly shall consist of the components listed below in the quantities specified in LED-330-3, plus all interconnecting plumbing and couplings. This assembly shall also include all instrumentation, wiring and bracketry required to mount and support the listed components plus the oxygen control module (LSC330-390) and the Grumman supplied carbon dioxide partial pressure sensor (LSC330-150). The package shall also include an electrical control harness, panels to provide interface connections for Heat Transport Section coolant, water, oxygen, electrical and control power. Provisions shall also be made for mounting Grumman supplied cover shields on the package.

LSC330-106	LSC330-113	LSC330-123
-107	-114	-124
-109	-115	-125
-110	-117	-127
-111	-118	-128
-112	-119	-134
	-122	-492

3.4.1.2.15 Cabin Heat Exchanger (LSC330-101). - The cabin heat exchanger shall provide for transfer of heat between the cabin gas and the Heat Transport Section coolant. The cabin heat exchanger shall include a self-contained, wick-filled reservoir of 2.5 pounds capacity for storage of moisture condensed by the heat exchanger. Wicking shall also be

3.4.1.2.15 (Continued)

provided on the discharge face of the heat exchanger to collect condensed moisture and deliver it to the reservoir. This wicking shall also provide for re- evaporation of water from the reservoir during those mission phases when the heat exchanger discharge gas is not saturated. This unit shall also include the interconnecting ducting to the cabin fans (LSC330-102) and all mounting bracketry required to support the fans as well as the cabin recirculation assembly (LSC330-191).

3.4.1.2.16 Cabin Fans (LSC330-102). - The two cabin fans shall provide sufficient recirculation of cabin gas through the cabin heat exchanger to provide adequate ventilation to the cabin and to meet the cabin heating and cooling requirements specified in Table IIA. The cabin fans will be turned on and off by electrical signals initiated from the cabin pressure switch (LSC330-308 or -323) and/or oxygen demand regulators (LSC330-306). The cabin fans shall be capable of operating independently of each other, each supplying one-half the maximum required recirculation of cabin gas. The fan shall be designed to permit operation at sea level for checkout purposes. Provisions for such sea level operation shall be designed for minimum effect on the weight and operational reliability of the fans.

3.4.1.2.17 Cabin Recirculation Assembly (LSC330-191). - The cabin recirculation assembly shall consist of the cabin heat exchanger (LSC330-101) and two cabin fans (LSC330-102). The assembly shall also include all required instrumentation, wiring and electrical connections. The assembly shall also include a replaceable inlet screen capable of filtering out particulate matters which may impair the performance of the cabin heat exchanger or the cabin fans. The screen shall be replaceable prior but not during flight.

3.4.1.2.18 Fan Differential Pressure Sensor (LSC330-124). - The fan differential pressure sensor shall sense the pressure differential across the suit circuit fans (LSC330-118) and provide signals to the fan condition signal control (LSC330-134) or to the automatic fan switch control (LSC330-123).

3.4.1.2.19 Fan Condition Signal Control (LSC330-134). - The fan condition signal control shall receive low differential pressure signals from the fan differential pressure sensor (LSC330-124) and the two fan identity signals from the fan selector switch. Depending on the identity signal present, the fan instrumentation control shall provide an isolated closed circuit for a caution signal if the low differential pressure signal is received with Fan #1 identity and another isolated closed circuit for a caution signal if the low differential pressure signal is received with Fan #2 identity. In addition, the control shall provide a third independent closed circuit (for activation of a panel light) whenever the low pressure signal is received, regardless of the fan identity signal present. The closing of the warning circuit and also the panel light circuit shall be delayed for 25 seconds when the low pressure signal has Fan #2 identity and instantaneous when it has Fan #1 identity.

3.4.1.2.20 PLSS Carbon Dioxide and Odor Removal Canister (LSC330-127). - The PLSS Carbon Dioxide and odor removal canister shall be designed to contain a single PLSS carbon dioxide and odor removal cartridge (LSC330-125) and to provide for removal and replacement of used PLSS carbon dioxide and odor removal cartridges without impairing the integrity of the suit circuit in accordance with 3.4.1.3.1(c). The PLSS carbon dioxide and odor removal canister shall be in parallel with the LEM carbon dioxide and odor removal canister (LSC330-110). Means shall be incorporated to prevent any foreign matter from leaving the PLSS carbon dioxide and odor removal canister and entering the suit circuit.

3.4.1.2.21 PLSS Carbon Dioxide and Odor Removal Cartridge (LSC330-125). - The carbon dioxide level in the atmosphere measured at the suit inlet shall be maintained within the limits prescribed in 3.4.1.3.4 by absorption in lithium hydroxide. Odors shall be removed from the atmosphere breathed by the crew by absorption in activated charcoal. The lithium hydroxide and activated charcoal shall be packaged together in replaceable cartridges. The cartridges shall incorporate filtering provisions to prevent escape of lithium hydroxide or activated charcoal.

3.4.1.2.22 Suit Supply Crossover Valve (LSC330-128). - Two manual valves shall be provided each of which shall have three detented positions for positive positioning and a total actuation travel not exceeding 190 degrees. Each valve shall perform the following functions:

3.4.1.2.22 (Continued)

Position I - Allow the conditioned oxygen from downstream of the suit circuit regenerative heat exchanger (LSC330-111) to enter one leg of the umbilical hose, and allow suit return oxygen to return thru the other leg of the umbilical hose upstream of the suit circuit relief valve (LSC330-117).

Position II - Allow the conditioned oxygen from downstream of the suit circuit regenerative heat exchanger to enter the leg of the umbilical that in Position I carried the suit return oxygen, and the suit return oxygen to return thru the leg of the umbilical that in Position I carried the conditioned oxygen.

Position III - Completely seal the umbilical from the suit circuit assembly (LSC330-190) package while allowing the flow that in Positions I and II went through the umbilicals to return directly to the suit loop. The pressure drop of the valve in this position shall be equal to the pressure drop specified in 3.4.1.3.7 within $^{+15}_{0}$ percent. In any of the three positions of the valve or during the actuation of the valve the suit circuit fans (LSC330-118) operation shall not be adversely affected.

3.4.1.2.23 Automatic Fan Switch Control (LSC330-123). - The automatic fan switch control shall automatically shut off the operating suit circuit fan and actuate the other suit circuit fan whenever the signal received from the fan differential pressure sensor (LSC330-124) indicates that fan pressure differential has fallen below allowable limits. The control shall provide an electrical signal to indicate that such a switch-over has occurred. The control shall permit being switched in and out of the circuit by manual features which shall enable the crew to independently operate either suit circuit fan. The control shall provide electrical signals when failure occurs in either the manual or automatic modes.

3.4.1.3 Atmosphere Revitalization Section - Performance Characteristics. -

3.4.1.3.1 Suit Circuit Pressure (Suit Coupled to Atmosphere Revitalization Section). - The suit circuit pressure, as measured between the suit circuit relief valve (LSC330-117) and the suit circuit diverter valve (LSC330-112) shall be:

3.4.1.3.1 (Continued)

(a) Normal suit circuit pressure shall be 5.0 ± 0.2 psia.

(b) Emergency suit circuit pressure shall be 3.7 + 0.2 - 0.0 psia.

(c) Minimum suit circuit pressure shall be 3.5 psia.

3.4.1.3.2 Suit Circuit Fan Performance. - The suit circuit fan shall be capable of providing a minimum suit circuit flow of 14.2 #/hr. dry gas at 70°F and 3.5 psia thru each suit.

3.4.1.3.3 Suit Supply Crossover Valve Outlet Temperature. - The temperature at the outlet of the suit supply crossover valve (LSC330-128) shall be adjustable as low as 60°F under all conditions except peak metabolic loads as defined in Table II-A and shall be adjustable to at least 42°F under all conditions when the primary loop of the Heat Transport Section is operating. Permissible suit inlet temperatures at peak metabolic load conditions shall be established by Grumman during the system integration study period. The overall conductance, for calculation purposes under pressurized cabin conditions, of each suit umbilical supply hose and each suit umbilical return hose may be assumed to be 1.8 BTU/hr.-°F.

3.4.1.3.4 Carbon Dioxide Partial Pressure. - The maximum carbon dioxide partial pressure of the atmosphere shall be 7.6 mm Hga.

3.4.1.3.5 Cabin Pressure. - The normal, steady-state cabin pressure during pressurized cabin operation shall be 5.0 ± 0.2 psia.

3.4.1.3.6 Oxygen Partial Pressure (in cabin and suit). - With the exception of the constituents specified in Table X, 3.4.1.3.4 and 3.4.1.3.11, the cabin and suit gas shall be pure oxygen. The minimum oxygen partial pressure in the atmosphere breathed by the crew shall be 160 mm Hga.

3.4.1.3.7 Suit and Umbilical Hose Pressure Drop. - The pressure drop of each suit, including both halves of the suit umbilical disconnect will be as shown in Figure 6. The total pressure drop of the suit umbilical hoses will be as shown in Figure 7.

3.4.1.3.8 Suit Circuit Pressure Drop. - Suit circuit pressure drop shall be determined.

3.4.1.3.9 Leakage. - External leakage of the Atmosphere Revitalization Section with the carbon dioxide and odor removal canisters (LSC330-110 and -127) closed, exclusive of the space suits, shall not exceed 0.01 lbs. per hour under emergency suit pressure with the cabin decompressed.

3.4.1.3.10 Cabin Temperature. - The cabin temperature shall be as specified in Table II-A.

3.4.1.3.11 Cabin Humidity. - The cabin relative humidity shall be as specified in Table II-A.

3.4.1.3.12 Condensation. - Condensation shall be prevented by the use of insulation, from forming on components whose external temperatures are below the cabin dew point at the operating conditions specified in Table II-A.

3.4.2 Oxygen Supply and Cabin Pressure Control Section. - The oxygen supply and cabin pressure control section shall perform the following functions:

(a) Maintain cabin pressure during pressurized cabin operation by supplying oxygen at a rate equal to cabin leakage plus crew consumption.

(b) Maintain space suit pressure during unpressurized cabin operation by supplying oxygen at a rate equal to Atmospheric Revitalization Section leakage plus space suit leakage plus crew consumption.

(c) Supply oxygen for repressurization of the cabin following partial or complete cabin decompressions.

(d) Supply a sufficient flow of oxygen to the cabin to delay the decrease of cabin pressure following a puncture of the cabin pressure shell during pressurized cabin operated as specified in 3.4.2.3.2.

3.4.2 (Continued)

(e) Provide for refill of the portable life support system (PLSS) primary oxygen storage tank.

(f) Prevent overpressurization of the cabin pressure shell.

(g) Permit deliberate decompression of the cabin.

(h) Permit emergency flow capability to the Atmospheric Revitalization Section.

(i) Control the operation of the cabin fan and suit circuit diverter valve.

3.4.2.1 Configuration. - The Oxygen Supply and Cabin Pressure Control Section shall consist of the items shown in LDW330-6000.

3.4.2.2 Component Functions. -

3.4.2.2.1 Oxygen Demand Regulator (LSC330-306). - Two pneumatic oxygen demand regulators shall be provided to maintain cabin pressure, or suit circuit pressure during depressurized cabin operation, by supplying pure oxygen to the suit circuit in sufficient quantity to replace that lost due to metabolic consumption by the crew and cabin or space suit and Atmosphere Revitalization Section leakage. Each regulator shall be capable of performing the foregoing functions automatically under the oxygen supply conditions specified in 3.4.2.3.15(a), (b), (c) and (d). Each regulator shall have two levels of pressure which it can maintain automatically - one for pressurized cabin operation and the other for depressurized cabin operation. Pressure level selection shall be manual. In addition to these two modes of automatic operation, each regulator shall include provisions for manual opening or closure and for electrical interlocks with the suit circuit diverter valve (LSC330-112), the cabin repressurization and emergency oxygen valve (LSC330-309) and the cabin fans (LSC330-102).

3.4.2.2.2 Oxygen Shut-Off Valves (LSC330-304). - A manually operated oxygen valve shall be provided for each of the following functions:

3.4.2.2.2 (Continued)

(a) Control flow from each oxygen tank into the oxygen control module (LSC330-390). Arrangement of these valves within the oxygen control modulate shall be such that opening of the ascent tanks valves cannot normally be accomplished without closing the descent tank valve. Capability to open ascent tank valves when descent tank valve is frozen in the open position shall be provided through an override feature.

(b) Control oxygen flow to refill the primary oxygen storage tanks of the PLSS.

3.4.2.2.3 Oxygen Check Valve (LSC330-305). - A check valve shall be provided to prevent reverse flow of oxygen from the oxygen control module (LSC330-390) to the descent stage oxygen tank.

3.4.2.2.4 Oxygen Pressure Relief Valve (LSC330-303). - The oxygen pressure relief valve shall prevent overpressurization of the Oxygen Supply and Cabin Pressure Control Section plumbing due to fluid being trapped in the oxygen control module (LSC330-390). The relief valve shall vent oxygen into the cabin to relieve excess pressure. The oxygen relief valve shall perform as specified in 3.4.2.3.13.

3.4.2.2.5 PLSS Oxygen Disconnect (LSC330-312). - The female half of the PLSS oxygen disconnect shall provide for coupling to the PLSS for refilling the primary oxygen storage tank of the latter. This half of the disconnect shall be self-sealing and shall require no tools for engaging or disengaging the PLSS. The male half of the disconnect shall provide a mounting support for the female half of the disconnect by engaging the latter without disabling its self-sealing feature. The male half shall have mounting provisions such that it is attachable to vehicle structure, and shall act as a dust cap for the female half of this disconnect while engaged.

3.4.2.2.6 Cabin Repressurization and Emergency Oxygen Valve (LSC330-309). - The cabin repressurization and emergency oxygen valve shall provide for delivery of oxygen directly to the cabin to slow the decay of cabin pressure resulting from a puncture of the cabin pressure shell as specified in 3.4.2.3.2 or to provide repressurization of the cabin as specified in 3.4.2.3.3. The valve shall respond to signals from the cabin pressure switch (LSC330-308 or -323) and shall incorporate manual override provisions for both opening and closure.

3.4.2.2.7 Cabin Pressure Switch (LSC330-308/-323). - The cabin pressure switch shall provide signals to close the suit circuit diverter valve (LSC330-112), open the cabin repressurization and emergency oxygen valve (LSC330-309) and actuate the low pressure warning when the cabin pressure falls to the pressure specified in 3.4.2.3.12(a). When the cabin pressure increases to the pressure specified in 3.4.2.3.12(b), the cabin repressurization and emergency valve shall close and the low pressure warning will be deactuated. When the cabin pressure falls to the value specified in 3.4.2.3.12(c) the cabin fan/fans will be deactivated. Increase of cabin pressure above that specified in 3.4.2.3.12(d) will reactivate the fan/fans. The design shall provide means to evacuate each bellows assembly separately for checkout at sea level. Each switch of LSC330-323 shall be capable of handling the combined power for the suit circuit diverter valve (LSC330-112) and the emergency oxygen valve (LSC330-309).

3.4.2.2.8 Cabin Pressure Relief and Dump Valve (LSC330-307). - The cabin pressure relief and dump valves shall prevent over-pressurization of the cabin in the event of malfunction of any of the oxygen inflow components or during the earth ascent phase of the mission, the profile of which is shown in Figure 1. Each valve will be sized to prevent over-pressurization during earth ascent phase of the mission. The maximum permissible cabin-to-ambient pressure differential shall be as specified in 3.4.2.3.4. The cracking pressure differential of the valves shall not be less than 5.4 psi. In addition, the valves shall provide for manual dumping of the cabin pressure by the crew as specified in 3.4.2.3.5. The interior handle shall be capable of overriding the valve open and close and of locking in the override and normal relieving positions. The exterior handle shall be capable of being overridden open and manually maintained in that position and 3.4.2.3.1.

3.4.2.2.9 Suit Circuit Oxygen Flow Limiters (LSC330-310). - Two oxygen flow limiters shall be provided in the oxygen control module (LSC330-390) to limit the normal and emergency oxygen flows to the Suit Control Circuit. Each limiter shall be located upstream of the oxygen demand regulators (LSC330-306). The flow limiter shall be designed to the flow specified in 3.4.2.3.11.

3.4.2.2.10 Check Valve - Manual Override (LSC330-313). - A check valve shall be provided to prevent backflow of oxygen from the oxygen control module (LSC330-390) to one of the ascent oxygen tanks. The check valve shall include capability for manual override to the closed or to the open position.

3.4.2.2.11 Oxygen Filter (LSC330-314). - The oxygen filter shall be provided in each of the oxygen supply lines from the supercritical oxygen storage assemblies to remove all particulate matter from the oxygen supply, which could cause a malfunction of any component within the ECS. The filter shall include an integral flow limiter designed for the flows specified in 3.4.2.3.10.

3.4.2.2.12 Oxygen Filter (LSC330-315). - An oxygen filter shall be provided in the inlet to the oxygen module (LSC330-390) from each oxygen tank, and in the module outlet to the PLSS, in order to remove all particulate matter from the oxygen supply which could cause malfunction of any components within the ECS.

3.4.2.2.13 Oxygen Hose (LSC330-316). - A flexible oxygen hose shall be provided to permit refill of the PLSS primary oxygen tank. The oxygen hose selected shall be capable of withstanding a pressure specified in 3.4.2.3.15.

3.4.2.2.14 Oxygen Control Module (LSC330-390). - The oxygen control module shall consist of the components listed below in the quantities specified in LED-330-3, plus all interconnecting plumbing and couplings. This assembly shall also include all bracketry required to mount and support the listed components and to mount the assembly itself. The module shall be capable of mounting to the suit circuit assembly (LSC330-190).

LSC330-303	LSC330-306	LSC330-313
LSC330-304	LSC330-309	LSC330-314
LSC330-305	LSC330-310	LSC330-315

3.4.2.2.15 Oxygen Hose Assembly (LSC330-391). - The oxygen hose assembly shall provide for the transfer of oxygen from the oxygen control module (LSC330-390) to the primary oxygen storage tank of the PLSS. The oxygen hose assembly shall consist of the oxygen hose (LSC330-316) and the PLSS oxygen disconnect (LSC330-312).

3.4.2.2.16 Oxygen Disconnect Support and Cap (LSC330-317). - The disconnect support shall mate with the vehicle (female) half of the GFE PLSS O_2 Disconnect. This fixture shall be designed for mounting to vehicle structure and shall act as a dust cap and mounting support while engaged with the PLSS O_2 disconnect. It shall incorporate a locking feature which will prevent the PLSS O_2 disconnect from disengaging under all vibration conditions.

3.4.2.3 Oxygen Supply and Cabin Pressure Control Section - Performance Characteristics. -

3.4.2.3.1 Suit Pressure Increase Rate. - With suit pressure initially constant, the rate of increase of suit pressure shall be limited as follows:

(a) First 1/2 psi may occur at any rate.

(b) Each succeeding increase of one psi shall occur in not less than 12 seconds under non-emergency conditions, and not less than 8 seconds under emergency conditions.

3.4.2.3.2 Cabin Repressurization Flow. - The oxygen control module (LSC330-390) shall be capable of delivering a minimum flow of 8.0 lbs/min. of oxygen to the cabin through the cabin repressurization and emergency oxygen valve (LSC330-309) during a cabin pressurization under the following conditions:

(a) O_2 module inlet pressure - 800 psi

(b) O_2 module inlet temperature 160°F

(c) Flow is through a single modulate inlet port.

The maximum flow rate shall be such that cabin pressure does not exceed suit circuit pressure during cabin repressurization.

3.4.2.3.3 Components Exposed to Low Temperature Extremes. - LSC330-304-306,-309,-310, -312, -315, -316, -390 may deviate from specification limits during exposure to temperature below the normal temperature range of 3.4.2.3.15(c), but shall meet all specification limits after returning to the normal temperature range.

3.4.2.3.4 Maximum Cabin Pressure. - The maximum cabin-to-ambient pressure differential shall be 5.8 psi.

3.4.2.3.5 Manual Cabin Pressure Dump Rate. - The manual cabin pressure dump rate for each valve shall be from 5.0 to 0.08 psia in 180 seconds maximum (without inflow). The dump rate for two valves open simultaneously shall be from 5.0 to 0.08 psia in 90 seconds maximum.

3.4.2.3.6 Cabin Volume. - The free cabin volume for ECS design is 235 cubic feet.

3.4.2.3.7 Oxygen Supply Component Leakage. - The total external leakage of all the oxygen supply components under maximum operating pressures shall not exceed 0.005 lb/hr of oxygen.

3.4.2.3.8 Cabin Pressure Relief and Dump Valve Leakage. - The cabin pressure relief and dump valve leakage shall not exceed 0.005 lb/hr. for each valve up to a pressure differential of 5.3 psi.

3.4.2.3.9 Maximum External Leakage. - The maximum external leakage of the LEM cabin from all sources will be 0.20 lbs. per hour at an internal pressure of 5.0 psia and 75°F.

3.4.2.3.10 Oxygen Filter (LSC330-314) Flow Rate. - The oxygen filter shall limit oxygen flow to 7.5 ± 0.2 lbs/hr. at 850 psia and 20°F.

3.4.2.3.11 Suit Circuit Minimum Inflow Rate. - The flow limiters (LSC330-310) shall be sized to allow a flow sufficient to maintain a minimum pressure of 3.5 psia in the suit circuit with the suit circuit relief valve (LSC330-117) failed open, and with 450 psia and 0°F at the O_2 module inlet.

3.4.2.3.12 Cabin Pressure Switch Setting. -

(a) On decreasing cabin pressure, suit circuit diverter valve (LSC330-112), cabin repressurization and emergency oxygen valve (LSC330-309) and low cabin pressure warning shall be actuated as follows:

LSC330-308	4.6 ± 0.05 psia
LSC330-323	4.5 ± 0.2 psia*

*The minimum differential pressure between activation and deactivation shall be 0.1 psi.

3.4.2.3.12 (Continued)

(b) Increasing cabin pressure will deactivate cabin repressurization and emergency oxygen valve and low cabin pressure warning as follows:

LSC330-308	4.8 ± 0.05 psia
LSC330-323	4.8 ± 0.2 psia*

(c) Decreasing cabin pressure below 3.05 ± 0.05 psia will deactivate cabin fans (LSC330-102).

(d) Increasing cabin pressure above 3.15 ± 0.05 psia will activate the cabin fans.

3.4.2.3.13 Oxygen Relief Valve Settings. - The relief valve pressure response characteristics shall be:

Full open pressure setting	1100 psi
Cracking pressure setting	1025 psi
Full closed pressure setting	980 psi

3.4.2.3.14 PLSS Refill Requirements. - The PLSS refill requirements will be 0.91 lb/refill at 850 psia.

3.4.2.3.15 Gaseous Oxygen Supply Characteristics. -

(a)	Normal pressure (regulated)	900 ± 50 psia
(b)	Normal pressure (unregulated)	75 to 100 psia
(c)	Normal temperature	0 to 160°F
(d)	Maximum pressure	1100 psia
(e)	Minimum pressure	5 psia
(f)	Maximum temperature	160°F
(g)	Minimum temperature	-200°F

*The minimum differential pressure between activation and deactivation shall be 0.1 psi.

3.4.2.3.16 Metabolic Consumption. - Metabolic Consumption of oxygen by the crew shall be as shown in Table IIA.

3.4.3 Heat Transport Section. - The Heat Transport Section shall perform the following functions:

(a) Provide heating or cooling for the Atmospheric Revitalization Section suit circuit.

(b) Provide cooling or heating of the cabin atmosphere as required.

(c) Provide active thermal control for all equipment requiring such control to maintain temperatures within prescribed limits. Such provision shall be redundant for those equipments whose operation is required to effect a successful abort.

(d) Provide a means for rejecting the vehicle's waste heat.

3.4.3.1 Configuration. - The Heat Transport Section shall consist of the items shown in LDW330-6000.

3.4.3.2 Component Functions. -

3.4.3.2.1 Coolant Pump (LSC330-201). - The coolant pumps shall be provided for recirculation of coolant fluid through the primary and redundant coolant loop. The pumps shall be part of two separate delivery loops; two pumps in the primary loop and one pump in the redundant loop. One pump shall be operated at a time and each shall be capable of satisfying the circulation performance requirements specified in 3.4.3.3.1, 3.4.3.3.2 and Table II-A.

3.4.3.2.2 Pump By-Pass Relief Valve (LSC330-202). - A pump by-pass relief valve shall be installed downstream of each coolant pump (LSC330-201). The valve shall provide for relief of excessive back pressure by routing a portion of the pump output directly to the pump inlet.

3.4.3.2.3 Cabin Temperature Control Valve (LSC330-203). - A cabin temperature control valve shall be provided to control the temperature of the coolant supplied to the cabin heat exchanger (LSC330-101) to maintain cabin gas temperatures within the limits specified in Table II-A. The

3.4.3.2.3 (Continued)

control valve shall sense the temperature of the coolant leaving the cabin heat exchanger. The valve shall respond mechanically to divert and modulate the necessary flow of coolant through the coolant regenerative heat exchanger (LSC330-204) for proper temperature control of coolant entering the cabin heat exchanger. The valve shall include provisions for manual reset of the control temperature and provide for manual control in the event of sensor failure.

3.4.3.2.4 Coolant Regenerative Heat Exchanger (LSC330-204). - The coolant regenerative heat exchanger shall provide for transfer of heat rejected from the electronic equipment and suit circuit regenerative heat exchanger (LSC330-111) to the coolant entering the cabin heat exchanger (LSC330-101) as required for heating of the cabin atmosphere.

3.4.3.2.5 Coolant Water Evaporator (LSC330-209). - A coolant water evaporator of porous plate design shall provide for rejection of waste heat from the Heat Transport Section primary loop coolant by evaporating water. The water evaporated shall be discharged through a Grumman supplied duct to the LEM ambient atmosphere environment specified in Table I. Pressure at the interface of the evaporator and the Grumman duct will not exceed 0.4 mm Hga. The coolant water evaporator shall be designed to preclude overcooling of the coolant beyond the limits specified in 3.4.3.3.1.

3.4.3.2.6 GSE Quick Disconnect (LSC330-214). - A male self-sealing quick disconnect half shall be provided to permit the use of GSE for coolant fill, cooling, and recirculation during ground checkout and operation of the Heat Transport Section. The disconnect half shall include a cap, to be installed after disconnecting the GSE, to protect against leakage due to failure of the self-sealing feature. It shall incorporate provision for mounting on the vehicle and will be used as a coolant outlet from the vehicle to the GSE. This disconnect half shall mate with the female half (LSC330-323) but it shall not couple with the Water Management Section disconnect half (LSC330-419) to the extent of unseating the self-sealing feature of either disconnect half.

3.4.3.2.7 Coolant Accumulator (LSC330-210). - The coolant accumulator shall maintain coolant pressure above coolant vapor pressure at all points in the primary coolant loop and absorb normal volumetric changes of the coolant mass. Coolant pressure shall be maintained mechanically and the accumulator shall provide an electrical signal in the event of excessive reduction of the coolant volume within the primary loop.

3.4.3.2.8 Coolant Filter (LSC330-212). - The coolant filter shall remove from the coolant stream all particles sufficiently large to cause malfunction of any of the Heat Transport Section components. The filter shall include an integral pressure relief by-pass feature to maintain coolant flow in the event the filter element becomes clogged. The filter element shall be replaceable prior to but not during the mission. The coolant filter shall be located upstream of the primary coolant loop pumps (LSC330-201).

3.4.3.2.9 Coolant Check Valve (LSC330-213). - Coolant check valves shall be provided downstream of each coolant pump to prevent reverse flow through inoperative pumps from "short-circuiting" the operating pump.

3.4.3.2.10 Suit Temperature Control Valve (LSC330-208). - The suit temperature control valve shall permit the crew to manually control the temperature of the ventilating gas delivered to their spacesuits. The valve shall effect this control by controlling the flow of warm coolant through the suit circuit regenerative heat exchanger (LSC330-111). The valve shall provide sufficient coolant flow to permit variation of the suit ventilating gas temperature throughout the range specified in 3.4.1.3.3.

3.4.3.2.11 Pump Differential Pressure Sensor (LSC330-218). - The pump differential pressure sensor shall sense the differential pressure across the coolant pumps (LSC330-201) in the primary coolant loop and provide signals to the auto. pump control switch (LSC330-217).

3.4.3.2.12 Control, Automatic Pump Switch (LSC330-217). - The automatic pump switch control shall shut off the operating pump (LSC330-201) in the primary coolant loop and actuate the other primary coolant loop pump whenever a signal is received from the differential pressure sensor (LSC330-218) indicating the pressure has fallen below the allowable limits. The pumps shall be cycled continuously until the required pump pressure can be maintained. The control shall provide an electrical signal to indicate pump switch-over has occurred. The control shall be capable of being manually overridden to permit the crew to select either pump. An electrical signal shall be provided when either pump fails to operate either in manual or automatic mode. If the pump should subsequently return to operation, the electrical signal shall terminate.

3.4.3.2.13 Coolant Recirculation Assembly (LSC330-290). - The coolant recirculation assembly shall consist of LSC330-201 (3), -202(3), -212, -213(3), and -218 plus all interconnecting plumbing and couplings. The assembly shall be divided internally into two separate delivery loops. The primary glycol loop section will contain two (2) -201 pumps in parallel, two (2) -202, two (2) -213 and one (1) -212. The redundant glycol loop section shall consist of the remaining one (1) pump 201, -202(1), and -213(1). In the event the redundant loop is deleted, the pump package design must be capable of converting, with a minimum of redesign, into a three pump primary loop.

3.4.3.2.14 Freon Boiler (LSC330-221). - The Freon boiler shall provide the necessary pre-launch cooling for the Heat Transport Section primary coolant loop. Freon 114 will be used in the Freon boiler. The boiler heat load shall be as specified in Table II-A.

3.4.3.2.15 Redundant Coolant Filter (LSC330-222). - The redundant coolant filter shall be external to the coolant recirculation assembly (LSC330-290) and shall remove from the redundant coolant loop stream all particles sufficiently large to cause malfunction of any of the Heat Transport Section components. The filter shall include an integral pressure relief by-pass feature to maintain flow in the event of clogging.

3.4.3.2.16 GSE Quick Disconnect (LSC330-223). - A female self-sealing quick disconnect half shall be provided to permit the use of GSE for filling, cooling and recirculation during ground checkout and operation of the Heat Transport Section. The disconnect half shall include a cap to be installed after disconnecting the GSE to protect against leakage due to failure of the self-sealing feature. It shall incorporate provision for mounting on the vehicle and will be used as a coolant inlet from GSE. This disconnect half shall mate with the male half (LSC330-214) but it shall not couple with the Water Management Section disconnect half (LSC330-418) to the extent of unseating the self-sealing feature of either disconnect half.

3.4.3.2.17 Redundant/Second Primary Coolant Water Evaporator (LSC330-224). - One Redundant/Second Primary Coolant Water Evaporator shall provide for the rejection of waste heat from the redundant coolant loop of the Heat Transport Section. Another shall provide for the rejection of a portion of the waste heat from the primary coolant loop of the Heat Transport Section. Evaporated water shall, in both cases, be discharged through

3.4.3.2.17 (Continued)

Grumman supplied ducts to the LEM ambient atmosphere environment specified in Table I. Pressure at the interfaces of the evaporator and the Grumman ducts will not exceed 0.4 mm Hga. The evaporator shall be of porous-plate design and shall meet the requirements of the redundant coolant loop as specified herein.

3.4.3.3 Heat Transport Section - Performance Characteristics. -

3.4.3.3.1 Coolant Temperature. - The coolant temperatures are as follows:

(a) The range of coolant temperature out of the primary coolant water evaporator (LSC330-209) shall be +32°F to 48°F.

(b) The range of coolant temperature out of the coolant water evaporator in the redundant coolant loop (LSC330-224) shall be 38°F to 64°F.

(c) The maximum coolant temperature into the primary coolant evaporator (LSC330-209) will be +110°F.

(d) The maximum coolant temperature into the coolant water evaporator in the redundant coolant loop (LSC330-224) will be 85°F.

3.4.3.3.2 Coolant Pump Pressure Rise. - The coolant pressure rise for the coolant pumps (LSC330-201) shall be 30 psi min. at 32°F, at the flow specified in 3.4.3.3.7(a).

3.4.3.3.3 Capacity. - The coolant capacity of the primary coolant loop of the Heat Transport Section will be approximately 44 lbs. of glycol-water mixture.

3.4.3.3.4 External Leakage Rate. - The total combined external leakage of the primary coolant loop components shall not exceed 1.215×10^{-4} cc/sec. of helium at a pressure differential of 45 psi at 70°F. The total combined external leakage of the redundant coolant loop components shall not exceed 1.0×10^{-4} cc/sec. of helium at a pressure differential of 45 psi at 70°F.

3.4.3.3.5 Vacuum Fill Requirements. - The Heat Transport Section shall be capable of withstanding an internal pressure of 500 microns in a sea level ambient pressure environment.

3.4.3.3.6 Coolant. - The coolant shall be Type II as specified in LSM-14-6001.

3.4.3.3.7 Coolant Flow Rates. - The nominal coolant flow rates shall be as follows:

(a) Primary coolant loop flow rate = 222 lbs/hr.

(b) Redundant coolant loop flow rate

(1) Coolant pump (LSC330-201) and redundant coolant filter (LSC330-222) = 222 lbs/hr.

(2) Coolant Water evaporator (LSC330-224) in redundant loop = 160 lbs/hr.

3.4.4 Water Management Section. - The Water Management Section shall perform the following functions:

(a) Provide storage capacity for all drinking, food preparation and cooling water required aboard the LEM at earth launch.

(b) Provide for delivery of the water output of the Atmosphere Revitalization Section Water separators to the suit circuit and Heat Transport Section Water evaporators.

(c) Provide for delivery of water from the water tanks to the Atmosphere Revitalization Section and Heat Transport Section water evaporators.

(d) Provide for refill of the cooling water tank of the Portable Life Support Systems.

(e) Provide an accumulator action for the redundant coolant loop of the Heat Transport Section.

3.4.4.1 Configuration. - The Water Management Section shall consist of the items shown in LDW330-6000.

3.4.4.2 Component Functions. -

3.4.4.2.1 Water Tank-Descent (LSC330-404). - The descent water tank shall provide adequate usable storage capacity to contain the water required through phase L-8 (descent) (see Table IIA) for drinking, food preparation, PLSS refill as specified in 3.4.4.3 and for cooling of the Heat Transport Section coolant. The tank shall be designed for positive expulsion of the stored water and shall be pressurized with nitrogen prior to earth launch.

3.4.4.2.2 Water Check Valve (LSC330-401). - Water check valves shall be provided for the following functions:

(a) Prevent water flow from the water control module (LSC330-490) to the water separators (LSC330-109).

(b) Prevent water flow from the water control module to the descent water tank (LSC330-404) and the ascent water tanks (LSC330-409).

(c) Prevent flow of water from the water separators to the water hose (LSC330-416), and, through the primary water pressure regulators (LSC330-415) to the descent water tank and ascent water tanks.

3.4.4.2.3 Water Shut-Off Valves (LSC330-402). - Manually operated water shut-off valves shall be provided for the following functions:

(a) Control the flow of water from the water control module (LSC330-490) to the water hose (LSC330-416) for drinking only.

(b) Control the flow of water from the water control module to the suit circuit water evaporator (LSC330-107).

3.4.4.2.4 PLSS Water Disconnect (LSC330-403). - A quick disconnect shall be provided for coupling the water hose (LSC330-416) to the PLSS and the drinking water dispenser. The disconnect shall be self-sealing and shall require no tools for engaging or disengaging the PLSS or the drinking water dispenser.

3.4.4.2.5 Water Evaporator Manual Feed Valve (LSC330-406). A feed valve shall be provided to manually control the flow of water to the Redundant/Second Primary Evaporator in the redundant coolant loop of the Heat Transport Section (LSC330-224).

3.4.4.2.6 Water Tank-Ascent (LSC330-409). - The ascent water tanks shall provide adequate usable storage capacity required for drinking, food preparation and cooling of the Heat Transport Section during ascent from the lunar surface. The tank shall be designed for positive expulsion of the stored water and shall be pressurized with nitrogen prior to earth launch.

3.4.4.2.7 Water-Coolant Isolation Valve (LSC330-410). - A water-coolant isolation valve shall be provided to isolate the water management system from the redundant glycol system. This valve shall be a puncture disc type. When actuated it shall provide an accumulator action for the glycol redundant coolant circuit.

3.4.4.2.8 Water Tank Selector Valve (LSC330-414). - A manually operated valve shall be provided for selection of the following modes of water Management Section operation:

(a) In the "DESCENT" position, the valve shall supply water from the descent water tank (LSC330-404) to the water hose (LSC330-416) for drinking only and the coolant water evaporators (LSC330-209 and LSC330-224) in the primary coolant loop of the Heat Transport Section and shall route the water output of the water separators (LSC330-109) to these coolant water evaporators.

(b) In the "ASCENT" position, the valve shall supply water from the ascent water tanks (LSC330-409) to the water hose (LSC330-416) for drinking only and the coolant water evaporators (LSC330-209 and LSC330-224) in the primary coolant loop of the Heat Transport Section and shall route the water output of the water separators (LSC330-109) to these coolant water evaporators.

(c) In the "EMERGENCY" position, the valve shall open the water/coolant isolation valve (LSC330-410), supply water from the ascent water tanks (LSC330-409) to the water evaporator (LSC330-224) in the redundant coolant loop of the Heat Transport Section and to the suit circuit water evaporator (LSC330-107), route the water output of the water separators (LSC330-109) to the water evaporator in the redundant coolant loop and the suit circuit water evaporator and seal off both the descent water tank (LSC330-404) and the ascent water tanks from the water hose (LSC330-416) and the coolant water evaporators (LSC330-209 and LSC330-224) in the primary coolant loop.

3.4.4.2.9 Water Pressure Regulator (LSC330-415). - The water pressure regulators shall sense suit loop pressure and reduce the water pressure from the tanks to a value compatible with the water separator pumping power. The regulators shall be used two in series in the primary water loop and one in the secondary water loop.

3.4.4.2.10 Water Hose (LSC330-416). - The water hose shall be provided to connect the water management system to the PLSS disconnect (LSC330-403) for filling the PLSS water storage tanks and supplying water for drinking and food preparation.

3.4.4.2.11 Water Control Module (LSC330-490). - The water control module shall consist of the components listed below in the quantities specified in LED-330-3 plus all interconnecting passages. This module shall also include all bracketry required to mount and support the components and to mount the assembly itself.

LSC330-401	LSC330-410
LSC330-402	LSC330-414
LSC330-406	LSC330-415

3.4.4.2.12 Ground Servicing Disconnect (LSC330-418). - A male self-sealing quick disconnect half shall be provided to permit the use of GSE for servicing of the Water Tanks (LSC330-404 and -409). The disconnect half shall include a cap, to be installed after disconnecting the GSE, to protect against leakage due to failure of the self-sealing feature. The disconnect half shall incorporate provision for mounting on the vehicle and will be used as a gas charging valve. This disconnect half shall mate with the female half (LSC330-419) but shall not couple with the Heat Transport Section disconnect half (LSC330-223) to the extent of unseating the self-sealing feature of either disconnect half.

3.4.4.2.13 Ground Servicing Disconnect (LSC330-419). - A female self-sealing quick disconnect half shall be provided to permit the use of GSE for servicing the Water Tanks (LSC330-404 and 409). The disconnect half shall include a cap, to be installed after disconnecting the GSE, to protect against leakage due to failure of the self-sealing feature. The disconnect half shall incorporate provision for mounting on the vehicle and will be used as a water fill valve. This disconnect half shall mate with the male half (LSC330-418) but shall not couple with the Heat Transport Section disconnect half (LSC330-214) to the extent of unseating the self-sealing feature of either disconnect half.

3.4.4.2.14 Water Shut-Off Valve (LSC330-420). - Water shut-off valves shall be provided to perform the following functions:

(a) Control the flow of water from the water control module (LSC330-490) to the coolant water evaporators (LSC330-209) and LSC330-224) in the primary coolant loop of the heat transport section.

(b) Control the flow of water from the descent water tank (LSC330-404) to the water hose (LSC330-416) for PLSS refilling.

3.4.4.2.15 Water Disconnect Support and Cap (LSC330-421). - The water disconnect support and cap shall provide a mounting support for the PLSS water disconnect by engaging the disconnect without disabling its self-sealing feature. It shall have mounting provisions such that it is attachable to vehicle structure, and shall act as a dust cap for the disconnect while engaged.

3.4.4.2.16 Water Check Valve Assembly (LSC330-492). - The water check valve assembly shall consist of one (1) water check valve (LSC330-401) and associated packaging, and shall be provided to perform the following functions:

(a) Prevent water flow from the water control module (LSC330-490) to the water separators (LSC330-109).

(b) Prevent water flow from the water hose (LSC330-416) through the water shut-off valve (LSC330-420) to the descent water tank (LSC330-404).

(c) Prevent water flow from the descent water tank through the shut-off valves (LSC330-402 and LSC330-420) to the coolant water evaporators - (LSC330-209 and LSC330-224) in the primary coolant loop of the heat transport section.

3.4.4.3 Water Management Section - Performance Characteristics. -

3.4.4.3.1 Water Storage. - Water storage characteristics of the water tanks shall be as follows:

3.4.4.3.1 (Continued)

(a) Initial (Fill) Pressure - The maximum initial pressure of the tanks shall be as follows:

(1) Descent Tank - 44.5 psia at 80°F

(2) Ascent Tanks - 43.0 psia at 80°F

(b) Expulsion Efficiency - With the initial fill pressures specified above, the minimum expulsion efficiency of the tanks shall be at least 98% of the total quantity of water loaded, down to a minimum loading valve of 100 lbs. in the Descent Tank (LSC330-404) and 20 lbs. in each of the Ascent Tanks (LSC330-409).

(c) Capacity - Any total quantity of water, to the following maximum quantities, may be loaded into the water tanks:

(1) Descent Tank - 367 lbs.

(2) Ascent Tanks - 47.5 lbs. each

(d) Tank Final Pressure - Tank final pressure shall be defined as that pressure which is attained upon explosion of all expellable water as defined in (b). This pressure shall be specified at 35°F, and shall be, for the quantities defined in (c), as follows:

(1) Descent Tank - 7.1 psia minimum

(2) Ascent Tanks - 6.4 psia minimum

3.4.4.3.2 Leakage. -

3.4.4.3.2.1 External Leakage Rate. - Leakage from the Water Management Section, exclusive of all water evaporators, shall not exceed 0.418 cc/hr of water at 50 psid and 70°F. The coolant water evaporators (LSC330-209 and LSC330-224) in the primary coolant circuit shall have a combined water leakage rate of not more than 0.090 cc/hr. at 6.5 psid and 70°F. The coolant water evaporator (LSC330-224) in the redundant coolant circuit and the suit circuit water evaporator (LSC330-107) shall have a combined water leakage rate of not more than 0.090 cc/hr. at 6.5 psid and 70°F.

3.4.4.3.2.2 Ground Service Disconnects Leakage Rate (External to Internal). - Each of the ground servicing disconnects (LSC330-418 and LSC330-419) shall not leak more than 1 x 10^{-2} scc/hr of helium when at an internal pressure of 500 microns absolute and in a helium ambient of 14.7 psia and 70°F.

3.5 Weight. - The maximum weight per unit shall not exceed that specified in Table VIII. Production deliveries which consist of the items listed below in the quantities as specified in LED-330-3 shall not exceed 233.37 pounds.

LSC330-190	LSC330-214	LSC330-307	LSC330-416
LSC330-191	LSC330-221	LSC330-316	LSC330-418
LSC330-203	LSC330-222	LSC330-317	LSC330-419
LSC330-204	LSC330-223	LSC330-323	LSC330-420
LSC330-208	LSC330-224	LSC330-390	LSC330-421
LSC330-209	LSC330-290	LSC330-404	LSC330-490
LSC330-210		LSC330-409	LSC330-492

3.6 Reliability. -

3.6.1 Mission Success. - The probability of success goal shall be .9995 for the completion of the mission requirements as detailed in Table III. This goal shall include all operating and non-operating phases of ECS life, i.e., launch, space flight and lunar excursion.

3.6.2 Crew Safety. - The probability of safety goal shall be 0.9999 for the completion of the requirements as detailed in Table III. The goal includes the minimum required performance during lunar excursion as well as hazardous conditions resulting from catastrophic failure throughout the mission, such as explosion or leakage causing damage to the other critical subsystems.

3.7 Marking. - All marking shall be in accordance with the requirements of Grumman Specification LSP-14-001. Metal impression stamps, including inspection stamps, shall not be used on production configuration hardware except on the nameplates.

3.7.1 Identification and Traceability. - Identification and traceability shall be in accordance with LSP-14-007.

3.8 Screw Assemblies. - All screw-thread assemblies shall be made vibration proof by use of lockwashers, lockwire, self-locking, or castle type nuts, or suitable retaining compound. Assembly screws shall be tight. The minimum length of screws and bolts shall be the shortest standard length that will provide at least $1\frac{1}{2}$ threads extending beyond nut. Maximum lengths shall be limited by the nearest larger standard screw length.

3.9 Elapsed Time Indicators. - ETI's shall be installed on the following equipment:

(a) One (1) on the primary coolant pump (LSC330-201) in the primary coolant loop of the Heat Transport Section.

(b) One (1) on each of the suit circuit fans (LSC330-118).

The indicators shall conform to Grumman Specification LSP-350-602 and will be supplied by Grumman.

3.10 Interchangeability. - All items having the same manufacturer's part number shall be functionally and dimensionally interchangeable. If changes in detail parts create tenuous situations as to assembly identification, at the option of Grumman, a dash number or new part number may be required.

3.11 Workmanship. - Workmanship on ECS Sections 1, 2, 3 and 4 shall be in accordance with high grade manufacturing practices.

4 QUALITY ASSURANCE PROVISIONS

4.1 General. - This section of specification establishes the general test and inspection requirements to be followed during the ECS test program. The vendor may propose additional tests to further increase the effectiveness of this program. The program shall consist of the following test categories:

(a) Development Tests (4.4)

(b) Qualification Tests (4.5)

(c) Post Qualification Tests (4.6)

(d) Acceptance Tests (4.7)

4.1.1 Level of Assembly for Tests. - Qualification, post-qualification, and production acceptance tests shall be performed at the highest level of assembly of the deliverable item for which the vendor is responsible. Design feasibility tests shall be conducted at levels of assembly which generate optimum design data.

4.1.2 Witnessing of Tests. - Grumman and the designated government inspection agency shall be advised at least one week in advance when tests are to be conducted so that a representative may be designated to witness the tests.

4.2 Test Facilities, Equipment and Tolerances. -

4.2.1 General. - Private, commercial or government test facilities may be used subject to Grumman approval.

4.2.2 Environmental Test Facilities. - The environmental test facilities used in conducting tests shall be capable of producing and maintaining the test conditions outlined in the test plan. These facilities shall be of a capacity and/or volume such that the items under test shall not interfere with the generation and maintenance of the required test conditions.

4.2.2.1 Cabin Simulator. - A cabin simulator which duplicates the LEM cabin internal volume and approximates its interior configuration shall be provided by the vendor and used for ECS testing. The walls of the cabin simulator and internal equipment shall be designed for permit simulation of cabin heat loads; the basic outline of the simulator is shown in Figure 3. Additional information for the design of this simulator will be supplied by Grumman.

4.2.3 Environmental Protection. - Equipment which requires special environmental control, such as hermetic sealing, insulation, thermal dissipation, vibration isolation, etc., shall be tested with the special environmental control applied.

4.2.4 Standard Conditions. - Test conducted without utilizing special environments or unless otherwise specified, shall be conducted under the following standard ambient conditions:

(a)	Temperature:	+77° ± 20°F
(b)	Relative Humidity:	90% or less
(c)	Barometric Pressure:	Local Atmospheric

4.2.5 Instrumentation Calibration. - All inspection, measuring, and test equipment shall be calibrated at intervals no greater than 60 days unless specifically excepted by Grumman against certified standards traceable to the National Bureau of Standards or which have known, valid relationships to national standards and are acceptable to Grumman. Records shall be maintained indicating the date of last calibration and due date. The due date shall be displayed on each item of inspection, measuring and test equipment or tools. The procedures and means shall be provided for periodic operational checks to be performed on each item of inspection, measuring and test equipment prior to use (e.g., warmup and setting of electronic instruments, and check of micrometers against shop standards). Calibration shall be subject to approval by Grumman.

4.2.6 Tolerances. -

(a) Test Equipment - Equipment used to measure certain ECS parameters agreed upon by Grumman and the vendor shall not be in error greater than 10% of the tolerances of the specified parameters in Table IV.

4.2.6 (Continued)

(b) Test Conditions - Except when otherwise specified, the maximum allowable tolerances of test conditions shall be as specified in Table IV. Specific tolerances shall be stated in the applicable individual test procedure.

(c) Performance Parameters - The vendor shall submit suggested maximum tolerance values for performance parameters and for the test equipment used to measure these parameters for Grumman approval. Specific tolerances shall be stated in the applicable individual test procedure.

4.2.7 Sensing and Recording Equipment. - Sensing and recording equipment of adequate response shall be used to obtain data during transient conditions of ECS Items operation requiring the evaluation of test data versus time.

4.2.8 Mounting Fixtures. - The mounting fixtures shall expose the items under test to the test environment in a manner that is representative of that in which it will be exposed in the LEM system. The test interface corresponds to the LEM primary structure interface with the ECS or its secondary supporting structures whichever is applicable. Grumman shall provide the secondary structure or design for the secondary structure where applicable for Qualification and Production Acceptance testing.

4.3 Test Procedures. - The vendor shall submit test plans to GAEC, as required by purchase order, for the development, qualification and acceptance testing of the ECS. The following test procedures shall apply whenever applicable tests form a part of the vendor's program. These procedures do not constitute the test program.

4.3.1 Performance Tests. - Performance tests shall demonstrate the capability of the test item to operate within specified design requirements under all operational and environmental conditions. These tests shall be conducted before, during and after each environmental, life and functional test or sequence of tests as appropriate.

4.3.1.1 Redundant Mode Operation. - The performance test of 4.3.1 shall exercise all redundant mode capabilities of the test item to assure that all parts or group of parts conform to the requirements of this specification.

4.3.2 Weight. - The dry test item shall be weighed and its weight shall not exceed the value specified in Table VIII. Development tests shall include determination of wet weights where applicable.

4.3.3 Thermal Vacuum. - The test item shall be placed in a vacuum chamber and be subjected to the pressure specified. While under vacuum, the item shall be subjected to the high and low temperature conditions of the test. All sides of the test item including any insulation shall simulate the actual installation so that the heat transfer environment is reasonably duplicated. Thermal dissipation of the equipment at test temperature shall be measured. Unless otherwise specified, the test item shall be continuously operated during the test and its performance monitored. Temperature probes shall be located internally in the equipment whenever possible and externally to demonstrate that the thermal gradients and component temperatures are acceptable.

4.3.4 Proof Pressure. - Proof pressure tests shall be conducted on all items which are subjected to internal or external fluid or gas pressure. Proof pressure shall be imposed on the item and held for at least 2 minutes. Evidence of permanent set or deformation, excessive leakage, or degradation of performance shall be cause for rejection.

4.3.5 Burst Pressure. - Burst test shall be conducted on all items which are subjected to internal or external fluid or gas pressure. The rate of application shall be in increments equal to 10 percent of the burst pressure until proof pressure is reached, then in increments of 5 percent of the burst pressure for a period of 15 seconds minimum per increment. During these tests, the pressure causing initial yield of the material shall be determined where practicable and the pressure recorded, together with a description of the nature of the failure.

4.3.6 Drainage. - With the test item in the normal launch attitude the fluid systems shall be completely filled with the working fluid then drained to the maximum extent possible. The fluids remaining shall be determined.

4.3.7 Shock. - The shock test shall be conducted in accordance with MIL-STD-810, Method 516, Procedure I, modified to a sawtooth shock pulse with a linear rise time of 11 ± 1 millisecond and a 1 ± 1 millisecond decay time. The measurement of the shock input shall be accomplished at the mounting interface of the test item. The test shall be conducted under standard conditions of 4.2.4.

4.3.8 Sustained Acceleration. - The test item shall be mounted on the test apparatus (centrifuge) in such positions to produce the accelerations in the directions specified. The test apparatus shall be of such size that the gradient across the test item shall not be greater than -15% to +30% of the input acceleration through the c.g. of the test item. The test shall be run at standard conditions of 4.2.4.

4.3.9 Vibration. - The vibration shall be accomplished in the three mutually perpendicular directions parallel to the spacecraft x-x, y-y and z-z coordinate axes except symmetrical items may require only two axes. The spacecraft coordinate axes are defined in the specification control drawing. Unless the item under test is mounted directly to primary structure, specified vibrations inputs shall be applied and monitored at the attachment of secondary structure to primary structure. Grumman will supply the vendor either design information for use in fabricating supports or the actual supporting secondary structure. Slip tables may be utilized where other test input methods are not practical. A sinusoidal resonance search shall be conducted at less than half of the required sinusoidal qualification test levels before any portion of the vibration test is conducted. The vibration amplification of any portion of the equipment shall be in accordance with 3.2.3.1. A complete log of each vibration test shall be maintained, including all resonant frequencies, vibration amplifications, instrumentation used, design changes made, and a detailed account of the performance of the item under test. If, in attempting to equalize vibration input or determine fixture resonances, it is necessary to apply vibration energy to test items prior to actual test, the vibration level shall be kept to a minimum and shall never exceed 50% of the actual test volume.

4.3.9.1 Vibration Fixtures. - The fixture, and its connection to the shaker head, shall be capable of transmitting the vibrations specified herein. It shall be a design objective that the fixture be free of resonances within the test frequencies. In any event, the fundamental

4.3.9.1 (Continued)

resonance of the fixture compensated for test item mass, shall be above 750 cps. The transverse motion (crosstalk) in any direction produced by these fixtures shall not exceed the vibration levels in the transverse direction specified herein. The requirements outlined above shall be verified by a sinusoidal vibration sweep at test frequencies using a mass simulated dummy test item. The vibration input for this sweep shall be monitored with tri-axial accelerometers.

4.3.9.2 Sinusoidal Vibration. - The vibration input levels shall be measured at or near the test item mounting location. Whenever more than four mounting locations exist, only four points need be monitored. Any accelerometer fastened at one of the mounting locations can be used as the servo control input provided that:

(a) The control input maintains levels at the test frequency within ± 1 db of the requirements.

(b) The level at any input location is within ± 4 db of the requirements at the test frequency.

(c) The average of all inputs at the test frequency is within ± 2 db of the requirements.

Exceeding the lower limits of the above tolerances shall be cause for rejection of the delinquent portion of the test and shall necessitate rerunning that portion of the vibration test. The recording of the accelerometer output signals shall be accomplished on a continuous recording device. The recording device shall have a response capability such that the complete signal wave form may be examined and analyzed.

4.3.9.3 Random Vibration. - The vibration input for this test shall be controlled from the same accelerometer as used to control the sinusoidal vibration test. The spectrum at test levels shall be analyzed and a plot of acceleration spectral density (g^2/cps) versus frequency shall be compiled for each random test. The analyzing filter shall have the following characteristics:

Frequency Range	B. W.
20 - 400 cps	12.4 cps
400 - 1200 cps	25.0 cps
1200 - 2000 cps	50.0 cps

4.3.10 Leak Detection. - All sealed enclosures of the test item shall be tested for leakage. Leakage test procedures shall be a function of the sealed enclosure physical and design parameters. The vendor shall propose suitable totalizing methods of leak detection for sealed items. Any detectable leak shall require that the item be submitted to a leakage rate test.

4.3.11 Leakage Rate. - When leakage rate tests are required, they shall be performed utilizing methods and procedures which are appropriate for the allowable leakage rates of the item being tested. The vendor shall submit leakage rate test methods and procedures for Grumman approval.

4.3.12 Oxygen Environment. - A chamber with the test item installed shall be evacuated to a pressure of 1 mm Hga or lower and then backfilled with dry oxygen gas per MIL-O-27210 to the test pressure. Water vapor shall be added to obtain the required humidity.

4.3.13 ECS Testing. - The ECS (see 6.1.1) shall be mated with the cabin simulator of 4.2.2.1. The types of tests to be accomplished shall shall include the following:

(a) Calibration

(b) Response

(c) Electrical

(d) Stability

(e) High Temperature

(f) Low Temperature

(g) Fluid Compatibility

(h) 100% Oxygen

(i) Endurance Run

(j) Endurance Load

(k) Leakage

The test plan shall indicate the duration, magnitude and conditions of the test that will be run during the tests mentioned above.

4.3.13 (Continued)

During the endurance run, ((i) above), the system shall be operated through a series of simulated missions with the duration and operational requirements of each mission phase corresponding to those of Table IIA. During each phase, the ECS shall be subject to the full range of loads listed for those phases in Table IIA, including peak metabolic load where applicable. Immediately prior to and after each "exploration" phase the cabin shall be decompressed to 0.02 psia or less and then repressurized.

During all tests of the ECS, the oxygen source shall have the characteristics specified in 3.4.2.3.15.

4.3.14 Temperature Tests. - The test item shall be placed in a chamber at atmospheric pressure and the internal chamber temperature raised to the maximum value specified. Stabilization shall have been achieved when two successive thermocouple readings, taken 15 minutes apart are within 1°C of each other. If practical, thermocouples shall be placed as close to the center of mass as physically possible.

4.3.14.2 Low Temperature. - The procedure for the high temperature test shall be repeated except that the equipment shall be cooled by suitable means to the low temperature extreme specified.

4.3.15 Fluid Compatibility. - Tests of the effects on the test item, of the chemical actions of fluids specified to be used, shall be determined for the following:

(a) Aging with fluids

(b) Drying in air

(c) Contact with vapors and most detrimental combinations thereof.

Test conditions shall simulate those encountered in actual application. Qualifying criteria shall be proposed in the test plan.

4.3.16 Humidity. - The humidity test shall be performed in accordance with MIL-STD-810, Method 507, except thatthe maximum test temperature shall be 110°F instead of 160°F; and the minimum test temperature shall be 40°F instead of 68°F to 100°F.

4.3.17 Fungus. - The fungus test shall be performed in accordance with MIL-STD-810, Method 508, Procedure I. This test may be deleted if documented evidence of the use of non-nutrient materials is submitted to and approved by Grumman.

4.3.18 Salt Atmosphere. - Salt atmosphere tests shall be performed as follows:

(a) Non-Cabin Equipment - A salt fog test shall be performed in accordance with MIL-STD-810, Method 509.

(b) Cabin Equipment - A corrosive contaminants test shall be performed in accordance with the following procedures:

(1) The test unit, under the ambient conditions of 4.2.4 shall be covered by a suitable enclosure throughout a test exposure of 48 hours. While covered by the enclosure the test unit shall be subjected to six (6) full surface wettings every eight (8) hours by atomization with a one percent (by weight) salt solution.

(2) Upon completion of the corrosive contaminants test, visual examination shall be performed after removal from the enclosure and observations of the test unit condition recorded. No attempt shall be made to clean the test unit during or after the test. Within one (1) hour, the test article shall be transferred to an oxygen humidity chamber and the oxygen environment test, per 4.3.12, shall be conducted as specified in Table VI-A.

4.3.19 Sand and Dust. - The sand and dust test shall be performed in accordance with MIL-STD-810, Method 510, except that the internal temperature of the test chamber shall be maintained at 90° ± 20°F for a period of 4 hours.

4.3.20 Explosion. - The explosion-proof test shall be performed in accordance with MIL-STD-810, Method 511, Procedure I.

4.3.21 Electromagnetic Interference. - ECS components and assemblies, complete with instruments, shall be subjected to an electromagnetic interference (EMI) test in accordance with Grumman Specification LSP-530-001. When a change is made which affects the EMI level, all ECS components and assemblies incorporating the change shall be retested.

4.3.22 Acoustics. - The ECS shall be subjected to an acoustical noise test as specified in 3.2.4 and shall not exceed the levels specified. Until such time as the ECS successfully passes the LEM acoustic noise test, the vendor shall assist Grumman in the resolution of problems that may arise.

4.3.23 Dielectric Strength. - The dielectric strength tests shall be conducted in accordance with MIL-STD-202, Method 301.

4.3.24 Insulation Resistance. - The insulation resistance test shall be conducted in accordance with MIL-STD-202, Method 302.

4.4 Development Tests. - Development tests are conducted to provide data to be used in the design or in the support of the design of a specific component, assembly, section or subsystem. Development tests shall be used to determine operating characteristics under off-design conditions. Overstress tests shall be conducted to provide failure mode and weak link characteristics for verification of analysis and determination of strength margins. In conjunction with the general thermal design, it is required that development tests be run on the equipment under simulated thermal environment to assure the compatibility of the thermal design with the specification. Vibration amplification factors shall be substantiated on the highest level of assembly during development testing. Development tests shall be categorized as follows:

(a) Component Design Feasibility Test (4.4.1)

(b) Logic Group Design Feasibility Tests (4.4.2)

(c) ECS Design Feasibility Tests (4.4.3)

4.4.1 Component Design Feasibility Tests. - Component design feasiblity tests shall include, but not necessarily be limited to, the tests listed in Table XII. Component design feasibility tests shall include all tests conducted for the following purposes:

(a) Component and part selection

(b) Investigation of the performance of preproduction components under various environmental conditions.

(c) Selection of materials

(d) Substantiation of safety margins or other analytical assumptions.

4.4.2 Logic Group Design Feasibility Tests. - Logic Group Design Feasibility tests shall include all tests conducted to investigate the performance of higher order of assemblies under simulated group and flight environments and off-design conditions. These tests shall include testing of assemblies and functional groupings of equipment under qualification test and off-design conditions. Logic group design feasibility tests shall include, but not necessarily be limited to, the tests listed in Table XII.

4.4.2.1 Overstress Tests. - As a culmination to the Logic Group Design Feasibility tests, the test article shall be tested to failure under systematically increasing dynamic and environmental stresses. Deviation of performance from that specified herein shall constitute a failure. The equipment shall dwell long enough at each increment of overstresses to stabilize conditions and complete an abbreviated operational test.

4.4.2.1.1 Selection of Stresses. - The Failure Mode Prediction Analysis shall provide the basis for the selection of stresses to be employed in the overstress tests. Only conditions from the launch and post launch phase of the mission shall be used for the overstress tests. If the stresses are due to a combination of dynamic and environmental conditions. the tests shall be performed under that combination of conditions. If the stresses are due to several dynamic and environmental conditions which are not in combination in the mission, the test increments shall be performed with each condition imposed separately. Each increment of the test conditions shall be increased in proportion to their values at mission levels.

4.4.2.1.2 Input Parameters. - The input parameters, such as pressure, temperature mass flow, voltage current, frequency, etc., shall be maintained at the values which were found to be most degrading during the preceding development tests.

4.4.2.1.3 Limited Life Items. - Items for which operating time or cycles significantly affects the level of stress at which failure occurs shall be tested with the increments of both stress and exposure time or number of cycles similarly proportioned to those used in the selected mission environment tests.

4.4.2.2 Analysis of Results. - The vendor shall perform the engineering analysis of the data generated by the overstress tests including a correlation with the Failure Mode Prediction Analysis for Grumman evaluation.

4.4.3 ECS Design Feasibility Tests. - Testing of a preproduction ECS shall be conducted in accordance with 4.3.13 for the purpose of demonstrating the performance of the ECS components and assemblies mated in a cabin simulator. Interactions, transients and redundant mode characteristics shall be observed to substantiate the correctness of the design for its intended mission.

4.5 Qualification Tests. - Qualification tests shall be performed on two (2) complete sets of production ECS items to demonstrate attainment of design objectives including margins of safety. The ECS items tested shall be subjected to the tests specified in Tables VA, VB, VIA and VIB with the instrumentation installed. Documented proof (testing as required) shall be provided to assure Grumman that component performance is not degraded when an instrument is removed. Instrumentation to be delivered as qualified items shall be subjected to qualification tests similar to those specified in Tables VA and VIA. The qualification tests categorized below shall be performed on separate units. ECS design feasibility tests shall include, but not necessary be limited to, the tests listed in Table XII.

(a) Design Limit Tests (4.5.4)

(b) Endurance Tests (4.5.5)

4.5.1 General. - The test sequence shall be in the order presented herein. The test item and test apparatus shall be subjected to inspection by Grumman quality control representatives. At convenient times prior to and after the tests, the test unit shall be examined to determine if it conforms to all requirements. At the option of Grumman, measurements shall be made of critical dimensions prior to start of the qualification tests. During the progress of tests, examinations may be made at the option of Grumman. The results of these examinations shall be a part of the qualification test data. Test items that have undergone qualification tests shall not be used for flight acceptance tests, nor shall they be used as flight equipment or flight spares. All items which have been subject to qualification tests, either individually or as part of a larger assembly shall be distinctively marked as qualification tested parts. Unless prior approval has been obtained from Grumman, items of equipment which have been qualification tested shall not be used for qualification testing as part of a higher order assembly.

4.5.2 Parts Failure and Replacement. - No replacement of parts, adjustments or maintenance shall be permitted during qualification tests except when approved by Grumman.

(a) If during a qualification test a failure occurs, the test shall be stopped and Grumman notified within 24 hours. Action may be initiated and testing resumed only with the approval of Grumman.

(b) In general, redesign of items failed during qualification tests shall be mandatory; however, Grumman shall have the option of approving part replacement and continuing the test.

(c) If a redesign and/or a retest of any item under test is required, the qualification test of that item shall be considered incomplete until the retest of the item in question has been completed to the satisfaction of Grumman.

(d) At the discretion of Grumman, redesign and retesting may be required of any item which has completed the qualification test program but fails or indicated weakness when retained to complete testing of other items.

4.5.3 Inspection Before Tests. - The test item shall be completely inspected for compliance with the drawings and specifications prior to qualification testing. Deviation from the drawings and specifications shall be cause for rejection unless approved by Grumman. Refurbished parts shall not be used on any test unit subjected to qualification tests.

4.5.4 Design Limit Tests. - The test item shall be successfully subjected to the Production Acceptance and Flight Simulation Tests of the Operational Cycle at design limit levels in accordance with Tables VA and VB.

4.5.5 Endurance Tests. - The test item shall be successfully subjected to a complete Operational Cycle plus one (1) additional Flight Simulation, at mission levels, in accordance with Table VIA and VIB.

4.5.6 Inspection After Tests. - After completion of the qualification test program, each test item shall be disassembled and subjected to a visual examination. Measurements shall be taken, as necessary to disclose excessively worn, distorted, or weakened parts. Photographs shall be taken of such discrepant parts and these photographs shall be included in the test report.

4.6 Post Qualification Tests. - At the completion of the qualification tests the test items shall be subjected to the following additional tests in order to increase confidence and provide additional information in equipment design life and strength. Post qualification shall not constrain production or be a cause for additional facility or STE requirements. Equipment failures experienced during post qualification testing shall be brought to the attention of Grumman for an evaluation of the impact on the flight worthiness of the equipment.

4.6.1 Overstress Tests. - The post qualification testing of the qualification test items which have not been subjected to Burst Pressure tests shall consist of overstress tests in the same mode or condition as selected for the Logic Group Design Feasibility overstress test as per 4.4.2.1, unless results of subsequent testing indicates otherwise.

4.7 Acceptance Test. - Acceptance tests are tests conducted on all deliverable items to provide assurance that the equipment performance is within the limits of the design parameters and that the equipment is free from material, construction, workmanship and functional deficiencies. All ECS items delivered for fulfillment of the purchase order shall be subjected to an acceptance test.

4.7.1 General. - The items, the test apparatus and the material entering into the manufacture of the items for fulfillment of the purchase order shall be subjected to inspection by authorized Grumman representatives. At convenient times prior to the tests and after the tests, the items shall be examined to determine if they conform to all requirements of the purchase order and specifications. During the progress of tests, examinations may be made at the discretion of Grumman. Generally, acceptance test conditions shall not be more severe than expected mission conditions, except proof pressure tests. Factors of safety and margins on life shall not be included in determining the environment for these tests. Items delivered by the vendor for use on LEM shall not contain a part which has been subjected to more than two (2) acceptance test programs nor a part which has been subjected to environments of an intensity higher than acceptance test levels, except that items for use on production deliveries or qualification tests may be subjected to no more than five (5) proof pressure tests.

4.7.2 Production Acceptance Tests. - Each production item deliverable to Grumman shall be subjected to the tests outlined in Tables VIIA and VIIB.

4.7.2.1 Abridged Acceptance Tests. - Each preproduction item deliverable to Grumman shall be subjected to the tests outlined in Tables VIIA and VIIB except that the vibration tests shall not be performed.

4.7.3 Inspection Before Acceptance Tests. - Each item shall be completely assembled in accordance with the drawings, then visually and dimensionally inspected before commencing the tests.

4.7.4 Acceptance Conditions. - Acceptance of any item shall be predicated on maintenance of all parameters within the limits specified throughout all tests.

4.7.5 Inspection After Test. - Upon completion of the acceptance tests, the item shall be subjected to a visual inspection. If any part is found to be defective, an approved part shall be supplied to replace it, and a suitable penalty test shall be conducted at the discretion of Grumman.

4.7.5.1 Penalty Test. - The maximum penalty test shall consist of a repetition of the test runs outlined in 4.7.2. Should the total running time during the penalty tests on an item (or any part thereof) exceed that normally accumulated during the production acceptance test runs, the item shall be rejected and shall become unacceptable for use on flight spacecraft.

4.7.5.2 Inspection After Penalty Test. - Upon completion of the penalty test, the item shall be visually inspected.

4.7.5.3 Inspection for Identification. - Inspect for compliance with Grumman Specification LSP-14-001.

4.7.6 Rejection and Retest. - Whenever in the opinion of the Grumman representative, there is evidence of malfunctioning or evidence that the item is not meeting the specified requirements, the difficulty shall be investigated and its cause corrected to the satisfaction of the Grumman representative before the test is continued. At the option of the Grumman representative, that portion of the test in which the difficulty was encountered shall be repeated.

5 PREPARATION FOR DELIVERY

5.1 Preservation, Packaging and Packing. - Preservation, packing and packaging shall be in accordance with Grumman Specification LSP-14-009.

5.2 Shock Sensor. - Each package shall include Grumman approved peak indicating accelerometers as a shock sensor during handling and transportation. The accelerometers shall be capable of indicating accelerations in three mutually perpendicular axes of the packaged item. The accelerometers shall be pre-set to indicate if excessive shock has been imposed on the unit.

6 NOTES

6.1 Definitions. -

6.1.1 ECS. - The "ECS" as used throughout this specification consists of a portion only of the complete Environmental Control Subsystem. This portion consists of the following sections:

(a) Atmosphere Revitalization Section

(b) Oxygen Supply and Cabin Pressure Control Section

(c) Heat Transport Section

(d) Water Management Section

6.1.2 System. - Complete primary function including ground support equipment (i.e., LEM, SM and CM).

6.1.3 Subsystem. - A major integral part of the system (LEM) representing the first level of functional breakdown below the total system level.

6.1.4 Section. - An arrangement of interrelated assemblies performing a certain function with the subsystem. A section can be classified in a general functional class.

6.1.5 Assembly. - An arrangement of subassemblies, components, and parts, performing one or more functions. The assembly represents the "Black Box" equipment level and will usually define the first level of subsystem external interfaces.

6.1.6 Subassembly. - The smallest grouping of components that can be physically separated from the assembly and defined in terms of its contributing functions.

6.1.7 Component. - The smallest grouping of parts that performs a single elementary function within a subassembly.

6.1.8 Part (Element). - The smallest basic element found in a component.

6.1.9 Item. - Equipment that is defined by the part number specified in LDW330-6000.

6.1.10 Model Classification. -

(a) Preproduction Model - This corresponds to an assembly of preliminary parts to prove the feasibility of a device, equipment, system, or principle, in rough form. It also corresponds to an assembly of the complete equipment constructed to demonstrate the technical soundness of the selected design. This model need not have the required final form factor or contain approved parts.

(b) Production Model - This is the flight weight model employing approved parts and fabricated with approved tooling and processes. This model is suitable for use in manned flight and represents the configuration which has successfully completed Component Design Feasibility tests and final design review.

6.1.11 Mockup, Soft. - The soft mockup shall be made basically of wood and shall simulate the form factors and major interfaces of all components.

6.1.12 Mockup, Hard. - The hard mockup shall be of metal representing the latest external configuration consistent with the delivery requirements. It shall be permissible for wood or other materials to be used for portions of the mockup. However, all flanges, bosses, and component mounting brackets representing critical dimensions shall be of metal. The dimensions of the ECS and components shall be within design layout tolerances taken from design layouts. If design layouts are not available, specifically prepared mockup drawings reflecting the latest external configuration may be used. Reconditioned or rejected components shall be used for the hard mockup whenever possible. If it is determined that specially prepared mockup drawings are required, approved from Grumman is necessary on those items to be constructed in this method.

6.1.13 Expendables. - Any gases, fluids, materials, chemicals or fuels that are consumed and must be continuously supplied for operation of the ECS.

6.1.14 Operational Cycle. - The period of time extending from the beginning of acceptance tests to the end of a mission that a system, subsystem, section, component or part is expected to operate under combined or sequential application of environments, induced or natural, including but not limited to, end-item test time, acceptance tests time, checkout time, transportation and handling time, the planned mission time and any critical abort or emergency conditions.

6.1.15 Final (Production) Design Review. - Grumman approved assembly drawings, specifications, appropriate reliability data and installation drawings following successful component design feasibility testing.

TABLE I

ENVIRONMENTAL AND LOAD CONDITIONS

NOTES:

1. Factors of Safety are not included in the levels specified herein and shall be applied to these values and self-generated loads of each ECS in accordance with Table I-A.

2. All accelerations are "earth g's." Multiply by earth weight or use 32.2 ft./sec^2 as appropriate.

3. Transportation, handling and storage in the shipping container shall not produce critical design loads on the ECS components and shall not increase the weight of the ECS.

(ns) These levels of environments and loads do not occur simultaneously.

(a) Pre-Launch Packaged

Acceleration: (ns)	2.67 g vertical with 1.0 g lateral applied to container
Shock: (ns)	Shock as defined in MIL-STD-810 (USAF) 14 June 1962, Method 516, Procedure III, Except, Engines, GSE, LEM structure and LEM Vehicle, which is to be supplied.

TABLE I (Continued)

(a) Pre-Launch Packaged (Continued)

Vibration: (ns)

The following vibration levels are specified during transportation, handling and storage. Vibration to be applied along three mutually perpendicular axes, applied to the container. (x, y and z) (Sweep at 1/2 octave per minute). Three times per axis from 5 cps to maximum cps and back to 5 cps

For 100 lb. or less		For 300 lb. or more	
cps	g or D.A.	cps	g or D.A.
5-7.2	.5 in D.A.	5-7.2	.5 in D.A.
7.2-26	± 1.3 g	7.2-26	± 1.3 g
26-52	.036 D.A.	26-52	.036 D.A.
52-500	± 5.0 g	-----	

NOTE: For 100 to 300# use figure 514-8 Method 514, MIL-STD-810 (USAF) 14 June 62 for max. frequency.

[1]Pressure: Atmospheric pressure corresponding to sea level to 50,000 ft.

Temperature: -65°F to +160°F

[1]Humidity: 0 to 100 percent relative humidity including condensation.

[1]Rain: Rain per MIL-STD-810, Method 506.

[1]Salt Spray: Salt Spray as encountered in a beach area (equivalent to spray of 5% salt solution in water for 50 hours)

[1]Ambient environments on outside of package.

TABLE I (Continued)

(a) Pre-Launch Packaged (Continued)

[1]Sand and Dust:	As in desert and ocean/beach areas, equivalent to 140 mesh silica flour with particle velocity up to 500 ft/min.
Fungus:	Fungus per MIL-STD-810, Method 508.
[1]Ozone:	Exposure with 0.05 parts/million concentration (1/2 toxic limit).
[1]Hazardous gases:	Explosion Proofing requirement defined in Method 511, MIL-STD-810 (USAF) 14 June 62
[1]Electromagnetic Interference:	In accordance with LSP-530-001

(b) Pre-Launch Unpackaged

Acceleration: (ns)	2.67 g vertical with 1.0 g lateral
Shock: (ns)	15 g 10-12 ms rise, 0-2 ms decay as in Method 516, Procedure I, Modified

[1]Ambient environments on outside of package

TABLE I (Continued)

(b) Pre-Launch Unpackaged (Continued)

Pressure:	Ambient ground level pressure. (Hermetically sealed units installed in the crew compartment shall be subjected to a limit pressure of 20.5 psi absolute during preflight checkout.)
Temperature:	0°F to 110°F ambient air temperature plus 360 BTU/ft^2 hr. up to 6 hr/day.
Humidity:	15% to 100% relative humidity including condensation.
Rain:	Same as (a) but no direct impingement.
Salt Fog:	As in MIL-STD-810 (USAF) Method 509.
Sand and Dust:	Same as pre-launch packaged.
Fungus:	Same as pre-launch packaged.
Ozone:	Same as pre-launch packaged.
Hazardous Gases:	Same as pre-launch packaged.
Electromagnetic Interference:	Same as pre-launch packaged.

(c) Launch and Boost

Accelerations:	X		Y		Z	
	g	Rad/Sec^2	g	Rad/Sec^2	g	Rad/Sec^2
Boost Cond. (S-1C)	+4.7	-	± .1	-	± .1	-
Max. q Cond. (S-1C)	+2.1	-	± .5	-	± .5	-
Cutoff Cond. (S-1C)	-2.6	-	± .1	-	± .1	-
Eng. Hardover (S-11)	+2.3	-	± .63	-	-	-
Eng. Hardover (S-11)	+2.3	-	-	-	± .63	-
Earth Orbit	0	0	0	0	0	0

TABLE I (Continued)

(c) Launch and Boost (Continued)

Vibration: The mission vibration environment is represented by the following random and sinusoidal envelopes considered separately:

Input to the support structure of the item(s) at the interface of the LEM primary structure and this supporting structure.

(1) For items whose source of vibration is Interior Primary Structure (reference Table IB Launch and Boost Interior).

Random:

10 to 23 cps	12 db/octave rise
23 to 80 cps	$0.015g^2$/cps
80 to 100 cps	12 db/octave rise
100 to 1000 cps	$0.036g^2$/cps
1000 to 1200 cps	12 db/octave decrease
1200 to 2000 cps	$0.015g^2$/cps

Sinusoidal:

5 to 16 cps	0.15 inch D.A.
16 to 100 cps	1.9g peak

(2) For items whose source of vibration is Exterior Primary Structure (reference Table IB Launch and Boost Exterior).

Random:

10 to 23 cps	12 db/octave rise
23 to 80 cps	$0.015g^2$/cps
80 to 105 cps	12 db/octave rise
105 to 950 cps	$0.044g^2$/cps
950 to 1250 cps	12 db/octave decrease
1250 to 2000 cps	$0.015g^2$/cps

Sinusoidal:

5 to 18.5 cps	0.15 inch D.A.
18.5 to 100 cps	2.7g peak

For design purposes the above random spectrum is applied for five minutes along each of the three mutually perpendicular axes, X, Y and Z. When applied in addition to the corresponding sinusoidal spectrum acting for five seconds at the natural frequency of the item being designed, it will adequately represent the vibration environment.

TABLE I (Continued)

(c) Launch and Boost (Continued)

Vibration: (Continued)

During the launch and boost phase of flight, the LEM is exposed to random vibration of varied levels and spectra for 17 minutes. During all but approximately 2.5 minutes of this period, the intensity of the random vibration is of such a low level that it is considered to be of negligible design significance. In addition, the launch and boost environment is considered to include peak vibration levels which are represented by the above sinusoidal vibration envelopes. The number of sinusoidal peaks for design can be considered to be one (1) percent of the natural frequency of the item being designed times the number of seconds of exposure. For design purposes, the above random spectrum is applied for five (5) minutes along each of the three mutually perpendicular axes, X, Y and Z. When applied in addition to the above sinusoidal vibration for 300 seconds exposure time it will adequately represent the vibration environment.

Acoustics:
Sound pressure:
levels external to LEM
(re .0002 dynes/cm^2)

Octave Band (cps)	C-5 Level (db)
9 to 18.8	142
18.8 to 37.5	141
37.5 to 75	141
75 to 150	138
150 to 300	134
300 to 600	130
600 to 1200	123
1200 to 2400	116
2400 to 4800	110
4800 to 9600	104
overall	147

Pressure: Atmospheric at sea level to 1×10^{-10} mm Hg.

Temperature:
0° to $+160^\circ$F uncontrolled cabin
$+40^\circ$ to $+100^\circ$F propulsion compartment
0° to $+110^\circ$F ambient S.L.
-65° to $+160^\circ$F external surface of LEM
0° to $+160^\circ$F equipment bay

TABLE I (Continued)

(c) Launch and Boost (Continued)

Humidity:	Same as pre-launch packaged.		
Hazardous gases:	Same as pre-launch packaged.		
Electromagnetic Interference:	Same as pre-launch packaged.		
Radiation:	As per 3.2.5.6.		

(d) Space Flight - Translunar

Acceleration:	X	Lateral	Pitch
Service propulsion system operating	-.450g	.110g	.373 rad/sec^2
Service propulsion system non-operating	0g	0g	0g
Shock:			
Condition transpositioning	-.84g	.12g	17.0 rad/sec^2

Pressure:	5.8 to .1 psia uncontrolled cabin 1 x 10^{-4} mm Hg uncontrolled vacuum (Space) 5.8 psia (O_2 controlled cabin) 1 x 10^{-10} mm Hg equipment bay
Temperature:	0° to 160°F in vacuum cabin & equip. bay +40° to 100°F in propulsion comp. +70° to +80°F in controlled cabin (O_2) Solar radiation 440 BTU/ft^2/hr.
Ozone:	To be determined.
Hazardous gases:	Same as pre-launch packaged.

TABLE I (Continued)

(d) Space Flight - Translunar (Continued)

Electromagnetic Interference:	Same as pre-launch packaged.
Radiation:	Van Allen, Solar Flare and Space background. To be defined as needed (inner belt 10 min. 1/2 hr. delay - outer belt 20 min. approximately) per 3.2.5.6.
Meteoroids:	No effort until directed by Grumman.

(e) Lunar Descent - Including separation, descent, hover and touchdown.

Accelerations:	X	Lateral	Pitch
Descent condition:	1.10g	.16g	.667 rad/sec^2

Shock: Landing condition:	$\pm$ 14.0 rad/sec^2 normal to 8.0g direction 10-20 ms rise time - ramp step shock 8.0g any axis
Vibration:	The mission vibration environment is represented by the following random and sinusoidal envelopes considered separately.

Input to the support structure of the item(s) at the interface of the LEM primary structure and this supporting structure.

(1) For items whose source of vibration is ascent stage primary structure (reference Table IB, Lunar Ascent and Descent-Ascent Stage).

Random:

10-20 cps	12 db/octave rise
20-100 cps	0.02g^2/cps
100-120 cps	12 db/octave decrease
120-2000 cps	0.01g^2/cps

Sinusoidal:

5 to 17 cps	0.01 inch D.A.
17 to 100 cps	1.5g peak

TABLE I (Continued)

(e) Lunar Descent (Continued)

Vibration: (Continued)

(2) For items whose source of vibration is Descent Stage Primary Structure (reference Table IB, Lunar Ascent and Descent-Descent Stage).

Random:

15-100 cps	$0.031g^2$/cps
100-175 cps	6 db/octave decrease
175-2000 cps	$0.010g^2$/cps

Sinusoidal:

5-20 cps	0.10 inch D.A.
20-100 cps	1.9g peak

For design purposes the above random spectra is applied for $12\frac{1}{2}$ minutes along each of the three mutually perpendicular axes, X, Y and Z. When applied in addition to the corresponding sinusoidal spectra acting for $12\frac{1}{2}$ seconds of the natural frequency of the item being design, it will adequately represent the vibration environment.

Pressure:	1×10^{-10} mm Hg uncontrolled vacuum (moon atmosphere) 5.8 psia (O_2) controlled cabin 10^{-10} mm Hg equipment bay
Temperature:	0° to +160°F in vacuum cabin and equipment bay Solar radiation 440 BTU/ft^2/hr. Lunar surface -300°F to +250°F depending on position of sun Space -460°F
Ozone:	To be determined

TABLE I (Continued)

(e) Lunar Descent (Continued)

Hazardous gas:	Same as pre-launch packaged.
Electromagnetic Interference:	Per LSP-530-001
Radiation:	Per 3.2.5.6.
Meteoroids:	No effort until directed by Grumman.

(f) Lunar Stay

	X	Lateral	Pitch
Accelerations:			
condition - at rest	1/6 g	- g	- rad/sec^2
Shock	Not critical		

Vibration:	Vibration due to vendors equipment shall be supplied by vendor. (Ascent and descent engines not operating).
Pressure:	1×10^{-10} mm Hg uncontrolled vacuum 5.8 psia (O_2) controlled cabin
Temperature:	0 to +160°F in vacuum cabin and equipment bay Solar radiation = 440 BTU/ft^2 hr. Lunar surface = -300°F to +250°F depending on position of sun Space = -460°F
Ozone:	To be determined.
Hazardous gas:	Same as pre-launch packaged.

(f) Lunar Stay (Continued)

Radiation:	Solar Flare and Space background to be defined as needed (as per 3.2.5.6).
Electromagnetic Interference:	Per LSP-530-001
Sand and Dust	This will be specified by Grumman
Meteoroids:	No effort until directed by Grumman.

(g) Lunar Ascent - Including ascent, rendezvous and docking

Acceleration:	X	Lateral	Pitch/Roll	Yaw
maneuver condition	1.2g	± .06g	± 1.25R/sec^2	±3.23
docking condition	along z axes	4		R/sec^2

Shock:	To be supplied by Grumman.
Vibration: (Ascent engine operating)	For Ascent Stage items (reference Table IB, Lunar Ascent and Descent-Ascent Stage vibration inputs are the same as for Lunar Descent, Table I(e) (1) except for $8\frac{1}{2}$ minutes for random and $8\frac{1}{2}$ seconds for sinusoidal vibration along each of the three mutually perpendicular axes, X, Y and Z.

NOTE: Vibration due to vendors equipment shall be supplied by vendor.

Pressure:	1×10^{-12} mm Hg uncontrolled vacuum 5.8 psia (O_2) controlled cabin
Temperature:	0 to +160°F in vacuum cabin and equipment bay Solar radiation = 440 BTU/ft^2 hr. Lunar surface = -300°F to +250°F depending on position of sun Space = -460°F

TABLE I (Continued)

(g) Lunar Ascent (Continued)

Ozone:	To be determined.
Hazardous gas:	Same as pre-launch packaged.
Radiation:	Solar Flare and Space background to be defined as needed. (per 3.2.5.6.)
Electromagnetic Interference:	Per LSP-530-001
Meteoroids:	No effort until directed by Grumman

TABLE I-A

ENVIRONMENTAL AND LOAD CONDITIONS

STRUCTURAL REQUIREMENTS

STRUCTURAL FACTORS OF SAFETY FOR TABLE I ENVIRONMENTS (3)

Environments	Limit Factors (3)	Ultimate Factors (3)
Accelerations	1.0 (c)	1.5 (c)
Shock	1.0 (c)	1.5 (c)
Vibration g^2/cps	$(1.3)^2$(c)	$(1.5)^2$ or 2.25 (c)
Vibration g and D.A.	(2) 1.3 (c)	1.5 (c)
Pressure Vessels (1) (Pressure only)	1.3	2.0 (p)
Pressure Vessels	1.0 (c)	1.5 (c)
Acoustics (db)	1.3 (c)	1.5 (c)
Temperature	1.0 (c)	1.0(T)1.5 (L) (c)
Humidity	1.0	-
Rain	1.0	-
Salt Spray	1.0	-
Sand and Dust	1.0	-
Fungus	1.0	-

(2) except for Pre-launch Vibration Limit Factor = 1.0
(1) proof pressure on all pressure vessles is 1.33 x Limit
(c) combined loadings (of Table I & self induced) shall be considered
(p) Pressure only (includes cabin, etc.)
(T) applies to Temperature
(L) applies to Thermal stress/load.
(3) These factors are to be applied to structural mission level loads conservatively selected to represent the maximum severity expected on the mission.

TABLE I-A (Continued)

STRUCTURAL FACTORS OF SAFETY FOR TABLE II ENVIRONMENTS (3)

Environments	Limit Factors (3)	Ultimate Factors (3)
Ozone	1.0	-
Hazardous gas	1.0	-
Radiation	1.0	-
Electromagnetic Interference	1.0	-
Meteoroids	1.0	-

(3) These factors are to be applied to structural loads conservatively selected to represent the maximum severity expected on the mission.

TABLE I-B Effectivity

Source of Vibration Inputs to Item's Support Structure

(Appropriate account must be taken for transmissibility of Secondary Structure)

MISSION PHASE	LAUNCH AND BOOST		LUNAR ASCENT AND DESCENT	
SOURCE / ITEM	EXTERIOR PRIMARY STRUCTURE	INTERIOR PRIMARY STRUCTURE	ASCENT STAGE PRIMARY STRUCTURE	DESCENT STAGE PRIMARY STRUCTURE
190	X		X	
191		X	X	
203		X	X	
204		X	X	
208		X	X	
209	X		X	
210	X		X	
214	X		X	
224	X		X	
221	X		X	
222		X	X	
223	X		X	
290		X	X	
307	X		X	
323	X		X	
390	X		X	
316		X	X	
317		X	X	
404		X		X
409	X		X	
416		X	X	
418	X		X	X
419	X		X	X
420		X	X	
421		X	X	
490		X	X	
492		X	X	

Glycol Loop Heat Loads

	Mission Phase Reference	Time ~ Minutes	Time ~ Hrs.	Cumulative Time from Launch ~ Hrs.	Suit Status Open/Closed	No. Men in LEM	Metabolic Data: O_2 Consum LB/MAN-HR	CO_2 Prod. LB/MAN-HR	Heat Prod BTU/M-HR	Peak Metab Occurs (5)	LiOH Heat Liberated BTU/HR: Sens.	Latent
Countdown	C	600	10	0	-	0	-	-	-		-	-
LEM Checkout	J-3	90	1.5	118.89	C	2	[illegible]	[illegible]	[illegible]		[illegible]	82
Separate	K-1	1.3	.022	118.91	C	2	.113	[illegible]	[illegible]		[illegible]	114
Orient LEM	K-2	28.7	.478	119.39	C	2	[illegible]	[illegible]	[illegible]		233	114
Insert into synch orbit	K-3	0.5	.008	119.40	C	2	.113	[illegible]	[illegible]		[illegible]	114
Coast to pericynthion	K-4	60	1.0	120.40	C	2	.113	.133	[illegible]		[illegible]	114
Initial powered descent	K-5	6.0	.10	120.50	C	2	.113	.133	[illegible]		[illegible]	114
Final powered descent	K-6	2.0	.033	120.53	C	2	.124	.146	756		[illegible]	126
Hover to touchdown	K-7	3.0	.050	120.58	C	2	.124	.146	756		[illegible]	126
Post land'g & pre-launch ck't	L-1	75	1.25	121.83	O	2	[illegible]	.137	714	*	240	120
One man explore	L-2	240	4.0	125.83	O	1	.091	[illegible]	554		34	46
Explore & replenish PLSS	L-3	240	4.0	129.83	O	1	[illegible]	.107	554		34	46
Report & replenish PLSS	L-4	480	8.0	137.83	O	2	[illegible]	[illegible]	412		166	82
One man explore	L-5	240	4.0	141.83	O	1	.091	[illegible]	554		34	46
Explore & replenish PLSS	L-6	240	4.0	145.83	O	1	.091	.107	554		34	46
Report & replenish PLSS	L-7	[illegible]	7.78	153.81	O	2	.081	.095	492		[illegible]	82
Pre-launch preparation (D)	L-8(D)	70	1.167	154.78	O	2	[illegible]	.096	[illegible]		168	82
Pre-launch preparation (A)	L-8(A)	.30	.50	155.28	O	2	.082	.096	500		[illegible]	82
Powered ascent	M-1	7.5	.125	155.40	O	2	.117	.137	714		[illegible]	120
Orbit contingency	M-2A	30	.50	155.90	O	2	.081	.095	492		[illegible]	82
Orbit contingency	M-2B	420	7.0	162.90	O	2	.081	[illegible]	[illegible]		[illegible]	82
Orbit contingency	M-2C	90	1.5	164.40	O	2	.081	[illegible]	492		[illegible]	82
Insert into transf. orbit	M-3	0.1	.002	164.40	C	2	.117	.137	714		[illegible]	120
Coast in transf. orbit	M-4	90	1.5	165.90	C	2	.091	.107	554		[illegible]	92
Rendezvous	M-5	24	.4	166.30	C	2	.101	.118	[illegible]		[illegible]	102
Dock	M-6	15	.25	166.55	C	2	.101	.118	[illegible]		[illegible]	102
Crew transfer	M-7	20	.333	166.88	C	2	.117	.137	714		240	120

	Cabin Design Limits: Temp °F	R.H. %	Cabin Heat Loads: Elec, Window & Asc Eng. [illegible] Max	Min	Structure @ [illegible] °F Max	Min	Cold Plate Loads BTU/HR: Low Temp. Elec. Max	Min	[illegible] Max	Min (4)	High Temp Elec. Max	Min	Suit Circuit Elect. Load ~ BTU/HR Max	Min	Redundant Loop Load BTU/HR Max	Min (4)
Countdown	-	-	0	0	0	0	273	-	150	-	261	-	-	-	-	-
LEM Checkout	70-80		+876	354	+14	-1044	2020	1744	1437		1403	1151	17	17		
Separate	70-84		986	526			2375	1870	1432		2410	1554	20	17		
Orient LEM	70-84		1064	503			2370	1866	1539		1965	1197	20	17		
Insert into synch orbit	70-84		1010	516			2375	1870	1664		1850	1148	20	17		
Coast to pericynthion	70-84		1054	505			2370	1866	1728		1820	1424	20	17		
Initial powered descent	70-90		1027	581	+666	-1327	2375	1881	1900		1880	1749	20	17		
Final powered descent	70-90		1046	599			2375	1870	1930		2370	1757	20	17		
Hover to touchdown	70-90		1025	598			2375	1870	1908		1748	1942	20	17		
Post land'g & pre-launch ck't	70-80	40-70	626	328			1780	1669	1770		1330	1084	17	17		
One man explore	36-80	40-100	341	171			506	454	1435		722	645	17	11		
Explore & replenish PLSS	36-80	40-100	284	103			532	454	1085		758	632	18	11		
Report & replenish PLSS	46-80	40-100	269	99			532	454	829	606	748	617	18	17		
One man explore	36-80	40-100	273	108			506	454	821	606	722	632	17	11		
Explore & replenish PLSS	39-80	40-70	284	103			532	454	829		758	632	18	11		
Report & replenish PLSS	46-80	40-100	271	98			532	453	829		748	621	18	17	(4)	870
Pre-launch preparation (D)	70-80	40-70	625	231			1905	1492	961		1096	959	17	17	-	→
Pre-launch preparation (A)	70-86	40-70	953	459	+666	-1327	2415	1920	783		2000	1227	20	17	1758	
Powered ascent	70-86	40-70	835	465			2368	1861	809		1497	1399	20	17	2205	
Orbit contingency	70-88	40-70	0/2561	0/2127	+39	-1074	1975	1866	0/1128		1806	1125	17	17	-	
Orbit contingency	66-80	40-70	0/950	0/677			533	480	0/568	565	700	542	17	17	-	
Orbit contingency	70-80	40-70	0/1103	0/866			2505	2001	0/1285		1504	932	20	17	-	
Insert into transf. orbit	70-95	40-70	2519/347	2098/324			2370	1870	800/1247		1612	1167	20	17	2360	
Coast in transf. orbit	70-95	40-70	2466/1099	1951/584			2710	2154	1615/1683		2108	1465	20	17	2795	
Rendezvous	70-95	40-70	2053/1071	1524/542			2580	2038	1650/1240		2143	1062	20	17	2670	
Dock	70-95	40-70	1965/1171	1271/477			2370	1867	1683/1752		2155	942	20	17	2500	
Crew transfer	35-80	40-100	915/249	+566/-100			0	-	1242/1278		0	0	0	-	-	

REMARKS:

(1.) POSITIVE SIGN INDICATES FLOW INTO CABIN

(2.) BATTERY & ECA LOADS ARE FOR NORMAL OPERATION, 4 BATT DESCENT, 2 BATT ASCENT

(3.) NUMERATOR IS FOR '0' [illegible] ORBIT CONTINGENCY DENOMINATOR IS FOR '9' HR ORBIT CONTINGENCY

(4) TO BE DETERMINED

(5) PEAK METABOLIC LOAD:
DURATION - 6 MIN
O_2 CONSUM - .149 LB/M-HR
CO_2 PROD - .174 LB/M-HR
$Q_{MET\ PEAK}$ - 900 BTU/M-HR

(6) ECS LOADS NOT INCLUDED ABOVE

(7) DESCENT ENGINE SOAK BACK OF 200 BTU/HR INCLUDED FOR LUNAR STAY

[redacted]

[redacted]

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TABLE II A

TABLE III

RELIABILITY MISSION PROFILE

ECS

	Time in Minutes				
	K Factor	1.0	10.0	0.001	0.01
	Total Phase Time	Non Boost Oper.	Boost Oper.	Non Boost Non Oper.	Boost Non Oper.
Prelaunch	600	600			
Launch & Earth Ascent	11.8	11.8			
Earth Orbit-Jettison	233.2	238	5.2		
Translunar Checkout	60	60			
Cont. Trip Thru Inject.	3677.4	3672	5.4		
LEM Chkt. Cont. Orbit	240	240			
Sept. To Insertion	14.9	14.9			
Hohmann Transfer	58.2	58.1	.1		
Powered Descent to Hover	6.4		6.4		
Powered Descent to TD	2.0		2.0		
Post Landing Checkout	75	75			
Lunar Stay	65	65			
Prelaunch Prep.	100	100			
Powered Ascent & Inject	5.6		5.6		
Transfer	42	42			
Rendezvous from 5n mi to 500 ft.	10	10			
Dock from 500 ft to Contact	15	15			
Additional Lunar for Crew Safety	[illegible]	1200			

[redacted]

TABLE IV

MAXIMUM TOLERANCES FOR TEST CONDITIONS

(1) Temperature: ± 3.0°F

(2) Sinusoidal Vibration Amplitude: ± 10%

(3) Sinusoidal Vibration Frequency: ± 2%

(4) Random Vibration: The vibration acceleration density applied to the test item shall be within ± 2 db of the specified test level over broad regions of the spectrum between 20 and 1000 cps and ± 4 db between 1000 and 2000 cps. The overall rms G applied shall be maintained within a tolerance of +15% / - 5%

(5) Shock Amplitude: ± 15%

(6) Acceleration: ± 15%

(7) Pressure:

- Barometric: ± 5%
- Gauge: ± 5%
- Vacuum: Pressure shall be lower than 1×10^{-5} mm of Hg

(8) Relative Humidity: +5% / -0%

(9) Time: ± 5%

(10) Simulated Thermal Radiation: Incident thermal radiation (0.03 to 2.0 microns) shall be simulated with sufficient precision so that the energy absorbed by the receiving body is within ± 5% of the energy expected to be absorbed from the applicable celestial body or other source. The vendor shall verify the calibration, collimation, uniformity of field and spectral distribution of all simulators to the satisfaction of Grumman

TABLE IV (Continued)

(11)	Black Space:	Space shall be simulated by chamger cold walls at liquid nitrogen temperatures or colder. The emittance of the chamber walls shall be at least 0.90 over the infrared portion of the electromagnetic spectrum. Chamber windows, uncooled doors, etc., shall not appear in the field of view of the equipment due to the large thermal effects which result.
(12)	Power:	± 5%
(13)	Weight:	± 1/2%
(14)	Coolant Flow Rate:	± 5%

GENERAL REQUIREMENTS

FOR

TABLES V, VI AND VII

(1) All conditions shall be imposed on the test unit in the unpackaged state.

(2) Test Procedures shall be in accordance with 4.3.

(3) The conditions specified in these tables shall be simulated in the sequence shown.

(4) Unless otherwise specified, the test unit shall be operated in accordance with its mission operating profile (Table III) and monitored in accordance with 4.3.1 during the tests.

(5) Conduct Performance Tests as per 4.3.1 before and after each environmental, life and functional test or sequence of tests as appropriate. As a minimum, these tests shall be conducted where specified in the tables.

(6) Unless otherwise specified, operating parameters, mass flow, internal pressure, voltage, current, etc., shall be maintained at their maximum or minimum tolerance levels, whichever is most wearing on the equipment.

* (7) Prior to the vibration portion of the test, a resonant frequency search shall be conducted between 5 to 2000 cps with any resonant frequencies and the approximate amplification mode recorded. The vibration RMS-g value shall be kept to a minimum not exceeding 50% of the qualification level.

(8) The sinusoidal and random vibration conditions shall be imposed sequentially.

(9) For all vibration test conditions refer to 3.2.3.1, for limitation of amplification factors.

(10) All sinusoidal vibration shall be run for one (1) sweep (rise & fall) per each of the three mutually perpendicular axes. (unless otherwise noted)

* Not applicable to Table VII.

GENERAL REQUIREMENTS (Continued)

FOR

TABLES V, VI AND VII

(11) Refer to Table IB for source of LEM vibration input to test unit support structure.

(12) All temperature test shall commence after the equipment has been stabilized at the specified temperature levels.

(13) Maximum allowable temperature shall not be exceeded on any unit under test at ambient pressure conditions.

(14) If any test called for cannot be conducted at the level of assembly stated, the test shall be conducted at the first practical lower level of assembly.

NOTE: Any deviation from the requirements of this table shall be subject to the approval of Grumman.

TABLE V-A

REQUIREMENTS FOR QUALIFICATION DESIGN LIMIT TESTS

Condition	Levels and Exposure	Remarks
Production Acceptance Test		In accordance with 4.7
Humidity-Temperature	In accordance with MIL-STD-810 (USAF), 14 June 1962, Method 507, Procedure 1. Modify high temperature to +110°F, low temperature to +40°F.	Equipment non-operating during test.
Salt Atmosphere (Non-Cabin Equipment)	In accordance with MIL-STD-810 (USAF) 14 June 1962, Method 509.	Equipment non-operating during test.
Sand and Dust (External to Vehicle)	In accordance with MIL-STD-810 (USAF) 14 June 1962, Method 510. Modify exposure at 77°F to four (4) hours.	Equipment non-operating during test.
Vibration	LAUNCH AND BOOST Input to Item 409 Test Unit Support Structure from Exterior Primary Structure. Sinusoidal: Sweep Rise and Fall at 3 oct/min. 5 - 18.5 cps: 0.23 inches D.A. 18.5 - 250 cps: 5.0 g 250 - 380 cps: 0.0013 inches D.A. 380 - 2000 cps: 9.2 g Random: 5 min/axis 15 min. total 10 - 23 cps: 12 db/oct. rise 23 - 80 cps: 0.033 g^2/cps 80 - 110 cps: 12 db/octave rise 110 - 950 cps: 0.10 g^2/cps 950 - 1200 cps: 12 db/octave decrease 1200 - 2000 cps: 0.033 g^2/cps	Tanks shall be pressurized to proof pressure. The vibration requirements may be run in the sequence shown for each axis before re-orientation of the test unit. The sinusoidal portions may be completed before running the random portions.

TABLE V-A (continued)

Condition	Levels and Exposure			Remarks
Vibration (continued)	LAUNCH AND BOOST (continued)			
	Input to Test Unit (other than Item 409) Support Structure from Exterior Primary Structure:			
	Sinusoidal: Sweep Rise & Fall at 3 oct/min	5 - 18.5 cps:	0.2 inches D.A.	
		18.5 - 250 cps:	3.5 g	
		250 - 380 cps:	0.0011 in. D.A.	
		380 - 2000 cps:	8.0 g	
	Random: 5 min/axis 15 min/total	10 - 23 cps:	12 db/oct. rise	
		23 - 80 cps:	0.025 g^2/cps	
		80 - 110 cps:	12 db/oct. rise	
		110 - 950 cps:	0.075 g^2/cps	
		950 - 1200 cps:	12 db/oct. decrease	
		1200 - 2000 cps:	0.025 g^2/cps	
	Input to Item 404 Test Unit Support Structure from Interior Primary Structure:			Tank shall be pressurized to proof pressure.
	Sinusoidal: Sweep Rise & Fall at 3 oct/min	5 - 16 cps	0.23 in D.A.	
		16 - 250 cps	2.9 g	
		250 - 420 cps	0.0009 in. D.A.	
		420 - 1000 cps	8.1 g	
		1000 - 2000 cps	9.2 g	
	Random: 5 min/axis 15 min total	10 - 23 cps:	12 db/oct. rise	
		23 - 80 cps:	0.033 g^2/cps	
		80 - 100 cps:	12 db/oct. rise	
		100 - 1000 cps:	0.08 g^2/cps	
		1000 - 1200 cps:	12 db/oct. decrease	
		1200 - 2000 cps:	0.033 g^2/cps	

TABLE V-A (continued)

Condition	Levels and Exposure	Remarks
Vibration (continued)	LAUNCH AND BOOST (continued) Input to Test Unit (other than Item 404) Support Structure from Interior Primary Structure: Sinusoidal: Sweep Rise & Fall at 3 oct/min 5 - 16 cps: 0.20 in. D.A. 16 - 250 cps: 2.5 g 250 - 420 cps: 0.0008 in. D.A. 420 - 1000 cps: 7.0 g 1000 - 2000 cps: 8.0 g Random: 5 min/axis 15 min. total 10 - 23 cps: 12 db/oct. rise 23 - 80 cps: 0.025 g^2/cps 80 - 100 cps: 12 db/oct. rise 100 - 1000 cps: 0.06 g^2/cps 1000 - 1200 cps: 12 db/oct. decrease 1200 - 2000 cps: 0.025 g^2/cps NOTE: The water tanks (LSC330-404 and 409) are considered structural items where fatigue will not be classified as a critical failure mode. These items have a separate Design Limit vibration profile as specified in this table. The force inputs from the secondary structure to the Descent Water Tank (LSC330-404) shall not exceed twenty (20) times the gross weight (20g's) when the tank is full. The input levels shall be recorded.	

TABLE V-A (continued)

Condition	Levels and Exposure			Remarks
Vibration (continued)	LUNAR ASCENT AND DESCENT			Tank shall be pressurized to proof pressure.
	Ascent Stage Equipment			
	Input to Item 409 Test Unit Support Structure from Ascent Stage Primary Structure.			
	Sinusoidal:	5 - 17 cps:	0.15 in. D.A.	
	Sweep Rise &	17 - 310 cps:	2.3 g	
	Fall at	310 - 500 cps:	0.00045 in. D.A.	
	2 oct/min.	500 - 2000 cps:	6.0 g	
	Random:	10 - 20 cps:	12 db/oct. rise	
	5 min/axis	20 - 100 cps:	0.045 g^2/cps	
	15 min. total	100 - 120 cps:	12 db/oct. decrease	
		120 - 2000 cps:	0.022 g^2/cps	
	Input to Test Unit (other than Item 409) Support Structure from Ascent Stage Primary Structure.			
	Sinusoidal:	5 - 17 cps:	0.13 in. D.A.	
	Sweep Rise &	17 - 310 cps:	2.0 g	
	Fall at	310 - 500 cps:	0.00039 in. D.A.	
	1/2 oct/min.	500 - 2000 cps:	5.2 g	
	Random:	10 - 20 cps:	12 db/oct. rise	
	21 min/axis	20 - 100 cps:	0.034 g^2/cps	
	63 min. total	100 - 120 cps:	12 db/oct. decrease	
		120 - 2000 cps:	0.017 g^2/cps	

TABLE V-A (continued)

Condition	Levels and Exposure			Remarks
Vibration (continued)	LUNAR ASCENT AND DESCENT (continued)			Tank shall be pressurized to proof pressure.
	Descent Stage Equipment			
	Input to Item 404 Test Unit Support Structure from Descent Stage Primary Structure.			
	Sinusoidal:	5 - 19 cps:	0.15 in. D.A.	
	Sweep Rise &	19 - 100 cps:	2.9 g	
	Fall at	100 - 310 cps:	2.3 g	
	2 oct/min.	310 - 500 cps:	0.00045	
		500 - 2000 cps:	6.0 g	
	Random:	15 - 100 cps:	0.069 g^2/cps	
	5 min/axis	100 - 175 cps:	6 db/oct. decrease	
	15 min. total	175 - 2000 cps:	0.022	
	Input to Test Unit (other than Item 404) Support Structure from Descent Stage Primary Structure.			
	Sinusoidal:	5 - 19 cps:	0.13 in. D.A.	
	Sweep Rise &	19 - 100 cps:	2.5 g	
	Fall at	100 - 310 cps:	2.0 g	
	1 oct/min.	310 - 500 cps:	0.00039 in. D.A.	
		500 - 2000 cps:	5.2 g	
	Random:	15 - 100 cps:	0.052 g^2/cps	
	$12\frac{1}{2}$ min/axis	100 - 175 cps:	6 db/oct. decrease	
	$37\frac{1}{2}$ min. total	175 - 2000 cps:	0.017 g^2/cps	

TABLE V-A (continued)

Condition	Levels and Exposure	Remarks
Acceleration	Condition / X axis / Y & Z axes / Duration A: + 7.0 g / - / 5 min. B: - 3.9 g / - / 5 min. C: + 3.5 g / ± 1.0 g / 5 min./Direction Combine X, Y and Z vectors for acceleration in Condition C	In accordance with 4.3.8.
Thermal Vacuum	Pressure: Less than 1 x 10^{-5} mm Hg. Location: / Chamber Wall Temperature / Exposure (Days) Equip. Bay or Cabin / 0°F / 1 +160°F / 1	In accordance with 4.3.3
Lunar Landing Shock	In accordance with MIL-STD-810, Method 516, Procedure I. Modify shock pulse to saw tooth 15g peak, 11 ± 1 ms rise, 1 ± 1 ms decay. Three (3) pulses per direction for a total of 18 pulses.	-
EMI		In accordance with 4.3.21
Explosion Proof	Non-Cabin Equipment only. In accordance with MIL-STD-810, Method 511, Procedure I.	
Burst Pressure Positive or Negative		In accordance with 4.3.5
Performance		In accordance with 4.3.1

TABLE V-B EFFECTIVITY

DESIGN LIMIT QUALIFICATION

TEST \ ITEM	190	191	203	204	208	209	210	214	221	222	223	224	290	307	316	317	323	390	404	409	416	418	419	420	421	490	492
Production Acceptance Test	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Humidity-Temperature	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Salt Atmosphere (non-cabin equipment)						X		X			X	X										X	X				
Sand and Dust (External to vehicle)								X			X			X								X	X				
Vibration	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Acceleration	X	X		X		X	X		X			X	X	X			X	X	X	X				X	X	X	X
Thermal-Vacuum	X	X				X						X	X				X	X									
Landing Shock	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
EMI	X	X					X				X						X										
Explosion Proof							X																				
Proof Pressure Negative	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X		X	X
Burst Pressure Positive	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X

TABLE VI-A

Requirements for Qualification Endurance Tests

Mission Phase	Condition	Levels and Exposure	Remarks
	Production Acceptance Test		In accordance with 4.7 Requirements for Production Acceptance Test.
	Integration and Checkout Subsequent to Acceptance Test and Prior to Launch	Ambient Conditions - The test items shall be operated for 2 equivalent missions (hours/cycles) in accordance with Table II-A.	This condition simulates the total operating time accumulated on the ECS items from point of shipment to Grumman through all checkout and acceptance testing prior to launch at AMR.
Ground Environment	Shock	In accordance with MIL-STD-810, Method 516, Procedure I. Modify shock pulse to saw tooth, 15g peak, 11 ± 1 ms rise, 1 ± ms decay. Three (3) pulse per direction for a total of 18 pulses.	Equipment non-operating during test.
	Performance Test		In accordance with 4.3.1

TABLE VI-A (Continued)

Mission Phase	Condition	Levels and Exposure	Remarks
Flight Simulation	Vibration & Temperature	Launch and Boost Temperature: 40°F for Water Management Section items 0°F for all other items Input to Test Unit Support Structure From Exterior Primary Structure: Sinusoidal Sweep Rise & Fall at 3 Oct/min.: 5-18.5 cps — 0.15 in. D.A.; 18.5-100 cps — 2.7g Random 5 min/axis 15 min. total: 10-23 cps — 12 db/oct. rise; 23-80 cps — $0.015g^2$/cps; 80-100 cps — 12 db/oct. rise; 100-950 cps — $0.044g^2$/cps; 950-1200 cps — 12 db/oct. decrease; 1200-2000 cps — $0.015g^2$/cps Input to Test Unit Support Structure from Interior Primary Structure: Sinusoidal Sweep Rise & Fall at 3 oct/min.: 5-16 cps — .15 in. D.A.; 16-100 cps — 1.9g Random 5 min/axis 15 min/total: 10-23 cps — 12 db/oct. rise; 23-80 cps — $0.015g^2$/cps; 80-100 cps — 12 db/oct. rise; 100-1000 cps — $0.036g^2$/cps; 1000-1200 cps — 12 db/oct. decrease; 1200-2000 cps — $0.015g^2$/cps	Vibration requirements for each axis may be run in the sequence shown before re-orientation of the equipment. The sinusoidal portions may be completed before running the random portions.

TABLE VI-A (Continued)

Mission Phase	Condition	Levels and Exposure	Remarks
Flight Simulation	Vibration & Temperature (Continued)	Lunar Ascent and Descent Temperature: 160°F Ascent Stage Equipment Input to Test Unit Support Structure from Ascent Primary Structure. Sinusoidal Sweep Rise & Fall at ½ Oct/min. — 7-17 cps: 0.1 in. D.A.; 17-100 cps: 1.5g Random 21 min/axis, 63 min. total — 10-20 cps: 12 db/oct. rise; 20-100 cps: $0.02g^2$/cps; 100-120 cps: 12 db/oct. decrease; 120-2000 cps: $0.01g^2$/cps Descent Stage Equipment Input to Test Unit Support Structure From Descent Stage Primary Structure. Sinusoidal Sweep Rise & Fall at 1 oct/min. — 5-20 cps: 0.1 in. D.A.; 20-100 cps: 1.9g Random 12½ min/axis, 37½ min. total — 15-100 cps: $0.031g^2$/cps; 100-175 cps: 6 db/oct. decrease; 175-2000 cps: $0.01g^2$/cps	

TABLE VI-A (Continued)

Mission Phase	Condition	Levels and Exposure	Remarks
Flight Simulation	Acceleration	Launch & Boost — Three minutes: +4.7g x-axis Space Flight — Three minutes: -2.6g x-axis	In accordance with 4.3.8.
	Thermal-Vacuum	Pressure: Less than 1 x 10^{-5} mm Hg Location / Chamber Wall Temp. / Exposure (Days) Cabin: 0°F, 1; +160°F, 1 Other: 0°F, 4; +160°F, 4	In accordance with 4.3.3.
	Lunar Landing Shock	In accordance with MIL-STD-810, Method 516, Procedure 1. Modify shock pulse to sawtooth, 15g peak, 11 ± 1 ms rise, 1 ± 1 ms decay. One (1) pulse per direction for a total of six (6) pulses.	
	Corrosive Contaminants (Cabin Equipment)	In accordance with 4.3.18(b).	Equipment non-operating during test for items 190 and 191.
	Oxygen Atmosphere	Cabin Equipment Only: Exposure Time (4) Days +0.0 -0.4 Control Pressure to 5.8 psia 100% O_2 O_2 Temp. / Exposure Time / R.H. 50°F, 1 Day, Less than 10% 90°F, 1 Day 50°F, 1 Day, 95% 90°F, 1 Day	In accordance with 4.3.12.

TABLE VI-A (Continued)

Mission Phase	Condition	Levels and Exposure	Remarks
Flight Simulation	Performance Test		In accordance with 4.3.1.
Unique Environments	Endurance Requirement		Repeat all conditions of the Flight Simulation Phase of the Mission.
	Fungus	In accordance with MIL-STD-810, Method 508, Procedure 1.	Equipment non-operating during test.
	Sand & Dust (Cabin Equipment)	In accordance with MIL-STD-810, Method 510, Modify exposure at 77°F to four (4) hours.	Equipment non-operating during test.

TABLE VI-B EFFECTIVITY

ENDURANCE QUALIFICATION

TEST \ ITEM	190	191	203	204	208	209	210	214	221	222	223	224	290	307	316	317	323	390	404	409	416	418	419	420	421	490	492
Acceptance Tests	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Integration & Checkout	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Shock (Ground)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Vibration & Temperature	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Acceleration	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Thermal-Vacuum	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Corrosive Contaminants (Cabin Equipment)	X	X	X	X	X					X			X		X	X	X	X			X			X	X	X	
Oxygen Atmosphere	X	X	X	X	X					X			X	X	X	X	X	X			X			X	X	X	
Shock (Lunar Landing)	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Drainage	X	X	X	X	X	X	X	X	X	X	X	X	X						X	X	X		X	X		X	
Leakage	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X		X	
Fungus	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Sand and Dust (Cabin Equipment)	X	X	X	X	X					X			X	X	X	X	X	X			X			X	X	X	

TABLE VII-A

REQUIREMENTS FOR PRODUCTION ACCEPTANCE TEST

Condition	Levels and Exposure	Remarks
Inspection		In accordance with 4.7.3.
Weight		In accordance with 3.5
Vibration Inputs to Support Structure	Random 5 min/axis, 15 min. total 10-20 cps: 12 db/oct. rise 20-100 cps: $0.02g^2$/cps 100-120 cps: 12 db/oct. decrease 120-2000 cps: $0.01g^2$/cps	Random vibration shall be along each of the mutually perpendicular axes.
Proof Pressure Positive		In accordance with 4.3.4
Leakage		In accordance with 4.3.10
Dielectric Withstanding Voltage		In accordance with MIL-STD-202, Method 301
Insulation Resistance		In accordance with MIL-STD-202, Method 302
Performance		In accordance with 4.3.1
Inspection		In accordance with 4.7.5

TABLE VII-B EFFECTIVITY

PRODUCTION ACCEPTANCE TEST REQUIREMENTS

TEST \ ITEM	190	191	203	204	208	209	210	214	221	222	223	224	290	307	308	316	317	323	390	391	404	409	416	418	419	420	421	490	492
Inspection	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Weight	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Vibration	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
Proof Pressure Positive	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		X	X	X	X	X	X	X	X		X	X
Leakage	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		X	X	X	X	X	X	X	X		X	X
Dielectric Voltage	X	X					X						X		X			X	X										
Insulation Resistance	X	X					X						X		X			X	X										
Performance	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Inspection	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

TABLE VIII

ITEM	DESCRIPTION	MAX. WT.* LBS/UNIT	REMARKS
122	Cartridge	7.60	Not included as part of 190 weight
125	PLSS Refill Cartridge	4.80	
190	Suit Circuit Assembly	109.28	Weight includes ducting, instrumentation, wiring connectors, panels, clamps and structural provisions.
191	Cabin Recirculation Assembly	20.31	
203	Cabin Temp. Control Valve	1.39	
204	Coolant Regen. HX	2.81	
208	Suit Temp. Control Valve	0.28	
209	Coolant Water Evap.	16.06	
210	Coolant Accumulator	3.85	

* All weights include EMI Suppresion, Sensors and conditioners for control functions.

TABLE VIII (Continued)

ITEM	DESCRIPTION	MAX. WT.* LBS/UNIT	REMARKS
214	GSE Quick Disconnect (Male)	0.14	
217	Auto. Pump Control Switch	1.56	
221	Freon Boiler	0.70	
222	Filter Redundant Loop	0.29	
223	GSE Quick Disconnect (Female)	0.24	
224	Redundant/Second Primary Water Evap.	6.11	
290	Coolant Recirculation Assembly	9.09	
307	Cabin Press. & Dump Valve	2.27	
308	Cabin Pressure Switch	1.52	If 308 is used in a delivery, then 323 is not used.
316	Oxygen Hose	0.30	
317	Oxygen Disconnect Support & Cap	0.17	

* All weights include EMI Suppression, Sensors and Conditioners for control functions.

TABLE VIII (Continued)

ITEM	DESCRIPTION	MAX. WT.* LBS/UNIT	REMARKS
323	Cabin Pressure Switch	1.86	If 323 is used in a delivery, then 308 is not used.
390	Oxygen Control Module	10.82	
391	Oxygen Hose Assembly	0.60	
403	PLSS Water Disconnect	0.23	
404	Water Tank - Descent	23.96	
409	Water Tank - Ascent	6.21	
416	Water Hose	0.56	
418	G. S. Water Disconnect	0.21	
419	G.S. Water Disconnect	0.25	
420	Water Shutoff Valve	0.25	
421	Water Disconnect Support & Cap	0.27	
490	Water Control Module	7.07	
492	Water Check Valve Assembly	0.12	

*All weights include EMI Suppression, Sensors and Conditioners for control functions.

TABLE IX

POWER REQUIREMENTS

ITEM	DESCRIPTION	POWER (WATTS) PEAK	AVERAGE *	REMARKS
102	Cabin Fan Motor	112.8	35.1	Power listed is for one fan
118	Suit Circuit Fan	585	146.5	
201	Glycol Pump & Motor	120	31.6	
217	Pump Controller	11	0.3	
112	Diverter Valve (Solenoid	16	0	
309	O_2 Repressurization Valve	22	0	
123	Control, Auto Fan Switch	8	0	
134	Control, Fan Condition	3.64	0	

* The power drawn under the conditions specified for phase L-1 in Table II-A.

NOTE: Signal Conditioners shall have a maximum power of 0.5 watts at 28 VDC each. The following instruments shall have a maximum power of 0.28 watts:

I 126

I 130

I 202

TABLE X

Gas	Maximum Allowable Concentrations: Partial Press. mm Hg	Maximum Allowable Concentrations: lb/lb mixture (3.5 psia)	Maximum Allowable Concentrations: lb/lb mixture (5.0 psia)	Production Rate lb/in-hr	Intermittent Flatus Production (2) lb of contaminant/dischg.
H_2	-	2.57×10^{-3}	2.57×10^{-3}	-	1.3×10^{-5}
[illegible]	[illegible]	8.85×10^{-5}	6.18×10^{-5}	-	2.8×10^{-9}
CH_4	-	2.65×10^{-2}	2.65×10^{-2}	-	3.33×10^{-5}
CO	.019	9.2×10^{-5}	6.45×10^{-5}	-	-
O_3	3.8×10^{-5}	3.15×10^{-7}	2.21×10^{-7}	(1)	-
NH_3	.019	5.58×10^{-5}	3.91×10^{-5}	average 1.5×10^{-5}	-
				peak 4.4×10^{-5}	-

(1) To be determined

(2) One discharge = 0.5 liters at body temperature and one atmosphere with three discharges/man-day.

TABLE XI

MEASUREMENT		IBM NO. (GF)	GROUP
Selected Suit Fan Current		1061	III
Primary Suit Compressor Speed		1071	III
Spare Suit Compressor Speed		1072	III
Primary Suit Compressor Selected	*	1081	II
Spare Suit Compressor Selected	*	1082	II
Primary Suit Compressor Failed	*	1083	II
Spare Suit Compressor Failed	*	1084	II
Prime Suit Compressor Fail	*	1085	II
Spare Suit Compressor Fail	*	1086	II
Suit Compressor Fail Selected	*	1087	II
H_2O Separator No. 1 Speed		1111	III
H_2O Separator No. 2 Speed		1112	III
Cabin Fan No. 1 Speed	*	1191	III
Cabin Fan No. 2 Speed	*	1192	III
Suit No. 1 Inlet Valve Closed		1201	II
Suit No. 2 Inlet Valve Closed		1202	II
Suit Press. Relief Valve Closed		1211	II
Suit Press. Relief Valve Open		1212	II
Suit Diverter Valve Closed		1221	II
Cabin Gas Return Valve Closed		1231	II

* Internally Generated Signal

TABLE XI (Continued)

MEASUREMENT		IBM NO. (GF)	GROUP
Cabin Gas Return Valve Open		1232	II
CO_2 Cartridge in Secondary Position		1241	II
CO_2 Cartridge in Secondary Position		1242	II
H_2O Separator No. 2 Selected		1251	II
H_2O Separator No. 1 Diff. Press.		1261	III
H_2O Separator No. 2 Diff. Press.		1262	III
Suit Inlet Temperature		1281	II
Suit No. 1 Outlet Temperature		1291	II
Suit No. 2 Outlet Temperature		1292	II
Suit Outlet Pressure		1301	III
CO_2 Partial Pressure	*	1521	IA
Compressor Discharge Temp.		1681	IA
Suit Hx Outlet Temp.		1701	IA
Coolant Pump No. 1 Speed	*	2011	III
Coolant Pump No. 2 Speed	*	2012	III
Coolant Pump No. 3 Speed	*	2013	III
Coolant Pump Diff. Pressure		2021	III
Coolant Accum. Low Level		2041	II
Coolant Pump No. 1 Selected	*	2071	II
Coolant Pump No. 2 Selected	*	2072	II
Coolant Pump No. 1 Fail	*	2931	II
Coolant Pump No. 2 Fail	*	2932	II

* Internally Generated Signal

TABLE XI (Continued)

MEASUREMENT	IBM NO. (GF)	GROUP
O_2 Reg. Valve 306A Locked Closed	3071	II
O_2 Reg. Valve 306A Locked Open	3072	II
O_2 Reg. Valve 306B Locked Closed	3073	II
O_2 Reg. Valve 306B Locked Open	3074	II
Emerg. O_2 Valve Locked Open (Man.)	3081	II
Emerg. O_2 Valve Locked Closed	3082	II
Suit/Water Diff. Press. (Primary)	4101	IA
Water Regulator Outlet Press. (Prim)	4091	III
Water Regulator Outlet Press. (Redun)	4092	III
Descent Tank Water Quantity	4581	IA
Ascent Tank No. 1 Water Quantity	4582	IA
Ascent Tank No. 2 Water Quantity	4583	IA

TABLE XI (Continued)

SIGNAL CONDITIONERS (INSTRUMENTATION)	USED ON ITEM NO.	GROUP
Suit Compressor Speed Sig. Conditioner	GF 1071, 1072	N/A
H_2O Separator Speed Sig. Conditioner	GF 1111, 1112	N/A
Cabin Fan Speed Sig. Conditioner Fan #2	GF 1192	N/A
Cabin Fan Speed Sig. Conditioner Fan #1	GF 1191	N/A
Coolant Pump Speed Sig. Conditioner	GF 2011, 2012, 2013	N/A
EMI SUPPRESSORS (INSTRUMENTATION)	USED ON IBM NO.	
Suit Inlet VPI Switch Suppressor	GF 1201	
Suit Inlet VPI Switch Suppressor	GF 1202	
Suit Press. Relief VPI Switch Suppressor	GF 1211	
Suit Press. Relief VIP Switch Suppressor	GF 1212	
Suit Diverter VPI Switch Suppressor	GF 1221	
Cabin Gas Return VPI Switch Suppressor	GF 1231	
Cabin Gas Return VPI Switch Suppressor	GF 1232	
CO_2 Cartridge VPI Switch Suppressor	GF 1241	
CO_2 Cartridge VPI Switch Suppressor	GF 1242	
H_2O Separator VPI Switch Suppressor	GF 1251	
Coolant Accum. Level Switch Suppressor	GF 2041	
O_2 Inflow VPI Switch Suppressor	GF 3071	
O_2 Inflow VPI Switch Suppressor	GF 3072	

TABLE XI (Continued)

EMI SUPPRESSORS (INSTRUMENTATION)		USED ON IBM NO.
O_2 Inflow VPI Switch Suppressor		GF 3073
O_2 Inflow VPI Switch Suppressor		GF 3074
Emerg. O_2 Repress. VPI, Switch Suppressor		GF 3082
Emerg. O_2 Repress. VPI, Switch Suppressor		GF 3081
Suit Fan Speed Sig. Cond. Suppressor	** **	GF 1071 GF 1072
H_2O Sep. Speed Sig. Cond. Suppressor	** **	GF 1111 GF 1112
Cabin Fan Speed Sig. Cond. Suppressor	**	GF 1191
Cabin Fan Speed Sig. Cond. Suppressor	**	GF 1192
Coolant Pump Speed Sig. Cond. Suppressor	**	GF 2011, 2 and 3
H_2O Sep. Diff. Press. Transducer Suppressor	**	GF 1261
H_2O Sep. Diff. Press. Transducer Suppressor	**	GF 1262
Suit Outlet Press. Transducer Suppressor	**	GF 1301
Coolant Pump Diff. Press. Transducer Suppressor	**	GF 2021
EMI SUPPRESSOR (POWER AND CONTROL)		LSC-330
Cabin Fan (Ripple Filter)		**-102
Suit Diverter Valve Switch Suppressor		-112
Suit Fan (Ripple Filter)		**-118
Suit Fan Control Box Suppressor		**-123
Cabin Press. Switch Suppressor		**-308

** Internal to Base Component

TABLE XI (Continued)

EMI SUPPRESSORS (INSTRUMENTATION)		USED ON IBM NO.
O_2 Inflow VPI Switch Suppressor		GF 3073
O_2 Inflow VPI Switch Suppressor		GF 3074
Emerg. O_2 Repress. VPI, Switch Suppressor		GF 3082
Emerg. O_2 Repress. VPI, Switch Suppressor		GF 3081
Suit Fan Speed Sig. Cond. Suppressor	** **	GF 1071 GF 1072
H_2O Sep. Speed Sig. Cond. Suppressor	** **	GF 1111 GF 1112
Cabin Fan Speed Sig. Cond. Suppressor	**	GF 1191
Cabin Fan Speed Sig. Cond. Suppressor	**	GF 1192
Coolant Pump Speed Sig. Cond. Suppressor	**	GF 2011, 2 and 3
H_2O Sep. Diff. Press. Transducer Suppressor	**	GF 1261
H_2O Sep. Diff. Press. Transducer Suppressor	**	GF 1262
Suit Outlet Press. Transducer Suppressor	**	GF 1301
Coolant Pump Diff. Press. Transducer Suppressor	**	GF 2021
EMI SUPPRESSOR (POWER AND CONTROL)		LSC-330
Cabin Fan (Ripple Filter)		**-102
Suit Diverter Valve Switch Suppressor		-112
Suit Fan (Ripple Filter)		**-118
Suit Fan Control Box Suppressor		**-123
Cabin Press. Switch Suppressor		**-308

** Internal to Base Component

TABLE XI (Continued)

EMI SUPPRESSOR (POWER AND CONTROL)	LSC-330
Coolant Pump (Ripple Filter)	**-201
Coolant Pump Control Box Suppressor	**-217
Oxygen Pressure Regulator Valve	-306
Coolant Pump Diff. Pressure Switch	**-218
Cabin Pressure Switch Suppressor	**-323
Suit Fan Condition Control Suppressor	**-124

**Internal to Base Component

TABLE XI (Continued)

MEASUREMENT	GF NO.	BOSS #	GROUP
CO_2 Absorber Inlet Pressure	1031	3	IA
CO_2 Absorber Inlet Temp.	1041	1	IA
CO_2 Absorber Inlet Humidity	6006	2	IA
CO_2 Absorber Outlet Humidity	6007	6	IA
CO_2 Absorber Diff. Temp.	6008	1, 5	IA
Suit Fan Flow Rate	6009	9	IA
CO_2 Absorber Diff. Pressure	6013	3	IA
Fan & Backflow Chk. Vlv. Diff. Press	6020	Existing Boss for Item 124	IA
Fan & Backflow Chk. Vlv. Diff. Temp.	6022	4, 8	IA
Suit Hx & Suit W/B O_2 Side Diff. Press.	6026	Existing Boss for Item 415 Bias	IA
Suit Hx O_2 Outlet Humidity	6027	13	IA
Suit No. 1 Inlet Flow Rate	6044	Existing Boss for CO_2 Sensor	IA
Suit No. 2 Inlet Flow Rate	6045	Existing Boss for CO_2 Sensor	IA
Suit No. 1 Outlet Humidity	6054	Existing Boss for CO_2 Sensor	IA
Suit No. 2 Outlet Humidity	6055	Existing Boss for CO_2 Sensor	IA
Cabin Fan No. 1 Diff. Temp.	6102	16	IA
Suit Regen Hx O_2 Side Diff. Press.	6110	14	IA
Suit Reg Hx O_2 Side Diff. Temp.	6111	10,15	IA
Cabin Fan No. 1 Diff. Press.	6117	17	IA
Cabin Fan No. 2 Diff. Temp.	6118	18	IA

TABLE XI (Continued)

MEASUREMENT	GF NO.	BOSS #	GROUP
Cabin Fan No. 1 Discharge Temp.	6119	16	IA
Suit Fan Inlet Manifold Temp.	6120	4	IA
Suit Hx & Suit W/B O_2 Side Diff. Temp.	6121	7, 12	IA
Suit Inlet Manifold Pressure	6122	Existing Boss for CO_2 Sensor	IA
Cabin Fan No. 2 Diff. Pressure	6127	19	IA
Cabin Fan No. 2 Discharge Temp.	6129	18	IA

TABLE XII

	101 A	101 D	102 A	102 D	106 A	106 D	107 A	107 D	109 A	109 D	110 A	110 D	111 A	111 D	112 A	112 D	113 A	113 D	114 A	114 D	115 A	115 D
PERFORMANCE TESTS																						
BUBBLE POINT																						
CALIBRATION	X	X	X		X		X		X	X			X		X		X		X			
OPERATIONAL			X						X	X	X	X				X		X	X	X	X	
PERFORMANCE MAP		X	X		X		X			X			X									
RESPONSE					X		X															
ELECTRICAL			X												X							
BASE POINT																						
STABILITY																						
ENVIRONMENTAL TESTS																						
VIBRATION I			X					X								X		X		X		
SHOCK																						
ACCELERATION																						
HIGH TEMPERATURE			X												X							
LOW TEMPERATURE			X												X							
ATTITUDE					X		X		X								X					
SAND AND DUST															X		X					
THERMAL VACUUM			X							X												
SALT FOG																				+		
THERMAL SHOCK																						
FLUID COMPATIBILITY	X		X		X		X			X			X		X		X		X	X	S	S
100% O_2 ENVIRONMENT																						
VIBRATION II										X												
LIFE TESTS																						
ENDURANCE			X				X		X						X		X			X		X
TEMPERATURE CYCLE																						
PRESSURE CYCLE	X				X		X						X									
FUNCTIONAL TESTS																						
REDUNDANT MODE																						
COLLAPSE PRESSURE	X		X		X		X				X	X	X									
EXAMINATION OF PRODUCT	X	X	X		X		X	X	X	X	X	X	X		X	X	X	X	X	X	X	X
HANDLE OVER TORQUE											X	X			X		X	X	X	X	X	X
LEAKAGE	X	X	X		X		X	X		X	X	X	X		X	X	X	X	X	X	X	X
PROOF	X				X		X			X	X	X	X				X	X	X	X	X	X
BURST I (2X)					X		X		X		X	X	X		X			X	X	X	X	X
DRAINAGE	X				X		X		X				X									
IGNITION			X												X		X			X	S	X
EMI			X												X		S			X	S	S
DIELECTRIC			X												X		X			X	S	X
CREEP																						
SLOSH																						
WEIGHT	X	X	X		X		X	X		X	X	X	X		X	X	X	X	X	X	X	X
BURST II (TO FAILURE)	X																					
OVERSPEED			A							A												
CONTAINMENT			X							X												

	117 A	117 D	118 A	118 D	119 A	119 D	122 A	122 D	123 A	124 A	124 D	125 A	125 D	127 A	127 D	128	134 D	190 A	190 D	191 A	191 D
PERFORMANCE TESTS																					
BUBBLE POINT																					
CALIBRATION	X		X	X	X				X	X						X	X	X	X	X	X
OPERATIONAL		X		X	X					X	X			X	X	X	X	X			
PERFORMANCE MAP			X	X													X		X	X	
RESPONSE	X			X														X	X	X	
ELECTRICAL				X																	X
BASE POINT																					
STABILITY																					
ENVIRONMENTAL TESTS																					
VIBRATION I					X				X	X						X			X		
SHOCK																					X
ACCELERATION																					
HIGH TEMPERATURE				X					X								X		X		
LOW TEMPERATURE				X					X								X		X		
ATTITUDE					X																X
SAND AND DUST																					
THERMAL VACUUM				X			X														
SALT FOG																					
THERMAL SHOCK																					
FLUID COMPATIBILITY	X		X	X	X		X			X						X		X	X		X
100% O_2 ENVIRONMENT																					
VIBRATION II		X		X							X						X				X
LIFE TESTS																					
ENDURANCE	X			X	X				X	X						X	X				
TEMPERATURE CYCLE																					
PRESSURE CYCLE																					
FUNCTIONAL TESTS																					
REDUNDANT MODE																		X	X		
COLLAPSE PRESSURE				X						X				X	X	X			X		
EXAMINATION OF PRODUCT	X	X	X	X	X		X	X			X			X	X	X	X	X	X	X	X
HANDLE OVER TORQUE	X			X	X				X	X	X			X	X	X	X	X	X		X
LEAKAGE		X		X	X				X	X				X	X	X	X	X	X		
PROOF		X		X	X					X				X	X	X					
BURST I (2X)		X		X	X									X	X						
DRAINAGE																			X		
IGNITION				X												X		X	X		X
EMI				X							X					S	X		X		X
DIELECTRIC				X					X	X						X	X		X		X
CREEP																					
SLOSH																					
WEIGHT	X	X	X	X	X		X	X	X	X	X			X	X	X	X	X	X	X	X
BURST II (TO FAILURE)									X								X		X		
OVERSPEED				A																	
CONTAINMENT				X																	

	203 A	203 D	204 A	204 D	208 A	208 D	209 A	209 D	210 A	210 D	214/223 A	214/223 D	217 A	217 D	220 A	220 D	221 A	221 D	222 A	222 D	290 A	290 D	224
PERFORMANCE TESTS																							
BUBBLE POINT																			X				
CALIBRATION	X	X	X		X		X		X	X	X		X	X	X		X		X		X	X	X
OPERATIONAL		X			X									X					X	X	X	X	
PERFORMANCE MAP		X	X				X								X		X					X	X
RESPONSE	X	X	X										X	X								X	
ELECTRICAL																						X	
BASE POINT																							
STABILITY		X																					
ENVIRONMENTAL TESTS																							
VIBRATION I		X																	X	X			
SHOCK							X			X													X
ACCELERATION										X													
HIGH TEMPERATURE														X							X	X	
LOW TEMPERATURE														X							X	X	
ATTITUDE															X								
SAND AND DUST										X													
THERMAL VACUUM																							
SALT FOG																							
THERMAL SHOCK																							
FLUID COMPATIBILITY	X	X	X		X		X		X	X	X				X		X		X		X	X	X
100% O_2 ENVIRONMENT																							
VIBRATION II							X		X	X				X								X	X
LIFE TESTS																							
ENDURANCE	X	X			X		X		X	X	X			X							X	X	X
TEMPERATURE CYCLE																							
PRESSURE CYCLE			X				X								X		X						X
FUNCTIONAL TESTS																							
REDUNDANT MODE																					X	X	
COLLAPSE PRESSURE	X		X				X		X	X				X	X		X					X	X
EXAMINATION OF PRODUCT	X	X	X		X		X		X	X	X		X	X	X		X		X	X	X	X	X
HANDLE OVER TORQUE		X			X																		
LEAKAGE	X	X	X		X		X		X	X	X			X	X		X		X	X	X	X	X
PROOF	X		X		X		X		X	X	X			X	X		X		X			X	X
BURST I (2X)																							
DRAINAGE	X		X		X		X		X	X	X				X		X		X			X	X
IGNITION										X				X								X	
EMI										X				X								X	
DIELECTRIC										X				X								X	
CREEP																							
SLOSH																							
WEIGHT	X	X	X		X		X		X	X	X			X	X		X		X	X	X	X	X
BURST II (TO FAILURE)		X	X		X		X			X	X		X	X	X		X		X			X	X
OVERSPEED																						A	
CONTAINMENT																						X	

	303 A	303 D	304 A	304 D	305 A	305 D	306 A	306 D	307 A	307 D	308
PERFORMANCE TESTS											
BUBBLE POINT											
CALIBRATION	X		X		X		X		X		X
OPERATIONAL	X		X					X		X	
PERFORMANCE MAP											
RESPONSE							X		X		
ELECTRICAL											
BASE POINT										X	
STABILITY									X		
ENVIRONMENTAL TESTS											
VIBRATION I											
SHOCK										X	
ACCELERATION										X	
HIGH TEMPERATURE							X		X		
LOW TEMPERATURE							X		X		
ATTITUDE									X		
SAND AND DUST									X		
THERMAL VACUUM											
SALT FOG											
THERMAL SHOCK											
FLUID COMPATIBILITY	X		X		X		X		X		X
100% O_2 ENVIRONMENT											
VIBRATION II							X			X	
LIFE TESTS											
ENDURANCE	X		X		X		X		X		X
TEMPERATURE CYCLE											
PRESSURE CYCLE											
FUNCTIONAL TESTS											
REDUNDANT MODE											
COLLAPSE PRESSURE											X
EXAMINATION OF PRODUCT	X		X		X		X	X	X	X	X
HANDLE OVER TORQUE			X				X			X	
LEAKAGE	X		X		X		X	X	X	X	
PROOF	X		X		X		X			X	
BURST I (2X)			X		X		X				
DRAINAGE											
IGNITION								X			X
EMI								X			
DIELECTRIC								X			X
CREEP											
SLOSH											
WEIGHT	X		X		X		X	X	X	X	X
BURST II (TO FAILURE)									X		
OVERSPEED											
CONTAINMENT											

COMPONENT AND LOGIC GROUP DEVELOPMENT TESTING STATUS

NOTES:

1. X - TEST TO BE PERFORMED.
2. A - THIS TEST WILL BE CONDUCTED IF ANALYSIS INDICATES NEED.
3. ◇ THIS TEST TO BE PERFORMED ON A LATER CONFIGURATION.
4. ■ TEST COMPLETED.
5. S - TESTED BY SIMILARITY.
6. + - THIS ITEM WILL BE CONSIDERED TYPICAL. ALL OTHER ITEMS WILL BE CONSIDERED TESTED BY SIMILARITY.

A - 106, 107
B - 110, 122
C - 125, 127
D - 111, 208

LOGIC GROUPS

E - 210, 204, 203, 208, 209, 214, 217, 220, 221, 222, 223, 290
F - 404, 409, 418, 490, 491, 419, 420, 421
G - 308, 307, 390, 391, 317 323
H - 190, 308, 390, 391

TABLE XII (Continued)

	309 A	309 D	310 A	310 D	312 A	312 D	313 A	313 D	314 A	314 D	315 A	315 D	316 A	316 D	317	323	390 A	390 D	390 C D	391 A	391 D
PERFORMANCE TESTS																					
BUBBLE POINT									X		X										
CALIBRATION	X				X		X		X		X				X	X	X			X	
OPERATIONAL							X		X		X							X			
PERFORMANCE MAP																					
RESPONSE	X																X				
ELECTRICAL	X																				
BASE POINT																					
STABILITY																	X				
ENVIRONMENTAL TESTS																					
VIBRATION I	X						X											X			
SHOCK																					
ACCELERATION																					
HIGH TEMPERATURE	X																				
LOW TEMPERATURE	X																				
ATTITUDE																					
SAND AND DUST					X																
THERMAL VACUUM																					
SALT FOG																					
THERMAL SHOCK																		X			
FLUID COMPATIBILITY	X				X		X		X		X					X	X	X		X	X
100% O_2 ENVIRONMENT																					
VIBRATION II																X					
LIFE TESTS																					
ENDURANCE	X						X									X				X	
TEMPERATURE CYCLE																					
PRESSURE CYCLE																		X		X	
FUNCTIONAL TESTS																					
REDUNDANT MODE																	X				
COLLAPSE PRESSURE																X		X		X	
EXAMINATION OF PRODUCT	X	X	X		X		X		X		X		X		X	X	X	X	X	X	X
HANDLE OVER TORQUE	X						X											X		X	X
LEAKAGE	X						X		X		X				X		X	X		X	X
PROOF	X						X		X		X				X		X	X		X	
BURST I (2X)	X						X		X		X				X						
DRAINAGE																					
IGNITION		X														X					
EMI		S														X					
DIELECTRIC		X														X					
CREEP																					
SLOSH																					
WEIGHT	X	X	X		X		X		X		X		X		X	X	X	X	X	X	X
BURST II (TO FAILURE)																		X		X	
OVERSPEED																					
CONTAINMENT																					

	401 A	401 D	402 A	402 D	403 A	403 D	404 A	404 D	406 A	406 D	409 A	409 D	410 A	410 D	414 A	414 D	415 A	415 D	416 A	416 D	418/419	420	421	490 A	490 D	491 A	491 D	492 D
PERFORMANCE TESTS																												
BUBBLE POINT																												
CALIBRATION	X		X		X	X	X		X		X		X				X	X				X	X	X	X	X	X	X
OPERATIONAL	X		X				X				X				X	X	X	X				X		X				X
PERFORMANCE MAP																												
RESPONSE																	X							X				
ELECTRICAL																												
BASE POINT							X				X														X			
STABILITY																												
ENVIRONMENTAL TESTS																												
VIBRATION I	X								X																			X
SHOCK							X				X							X							X			
ACCELERATION							X				X							X							X			
HIGH TEMPERATURE																	X											
LOW TEMPERATURE																	X											
ATTITUDE																	X											
SAND AND DUST						X										X												
THERMAL VACUUM																												
SALT FOG																												
THERMAL SHOCK																												
FLUID COMPATIBILITY	X		X		X	X	X		X		X		X			X	X	X				X	X		X	X	X	X
100% O_2 ENVIRONMENT																												
VIBRATION II							X				X							X				X	X		X		X	
LIFE TESTS																												
ENDURANCE							X		X		X				X								X	X	X		X	
TEMPERATURE CYCLE																												
PRESSURE CYCLE							X				X						X										X	
FUNCTIONAL TESTS																												
REDUNDANT MODE																								X				
COLLAPSE PRESSURE							X				X																X	
EXAMINATION OF PRODUCT	X		X		X	X	X		X		X		X		X	X	X	X	X			X	X	X	X	X	X	X
HANDLE OVER TORQUE			X						X						X							X		X				
LEAKAGE	X		X		X	X	X		X		X		X		X	X	X	X				X		X	X	X	X	X
PROOF	X		X				X		X		X		X			X		X				X			X		X	X
BURST I (2X)	X		X						X				X			X		X										
DRAINAGE											X											X		X			X	X
IGNITION																												
EMI																												
DIELECTRIC																												
CREEP							X				X																	
SLOSH							X				X																	
WEIGHT	X		X		X	X	X		X		X		X			X		X	X			X	X		X		X	X
BURST II (TO FAILURE)							X				X											X			X		X	X
OVERSPEED																												
CONTAINMENT																												

	Grp. A A	Grp. A D	Grp. B A	Grp. B D	Grp. C A	Grp. C D	Grp. D A	Grp. D D	Grp. E A	Grp. E D	Grp. F A	Grp. F D	Grp. G A	Grp. G D	Grp. H A	Grp. H D	ECS D
PERFORMANCE TESTS																	
BUBBLE POINT																	
CALIBRATION	X		X	X	X	X	X				X			X			X
OPERATIONAL														X			
PERFORMANCE MAP				X													
RESPONSE							X							X			X
ELECTRICAL																	X
BASE POINT										X						X	
STABILITY														X			X
ENVIRONMENTAL TESTS																	
VIBRATION I																	
SHOCK				X		X				X						X	
ACCELERATION																X	
HIGH TEMPERATURE																	X
LOW TEMPERATURE																	X
ATTITUDE																	
SAND AND DUST																	
THERMAL VACUUM																	
SALT FOG																	
THERMAL SHOCK																	
FLUID COMPATIBILITY				X		X											X
100% O_2 ENVIRONMENT																	X
VIBRATION II				X		X				X						X	
LIFE TESTS																	
ENDURANCE																	X
TEMPERATURE CYCLE																	
PRESSURE CYCLE																	
FUNCTIONAL TESTS																	
REDUNDANT MODE																	X
COLLAPSE PRESSURE																	
EXAMINATION OF PRODUCT																	
HANDLE OVER TORQUE																	
LEAKAGE			X	X	X	X				X						X	X
PROOF																	
BURST I (2X)																	
DRAINAGE																	
IGNITION																	
EMI										X						X	
DIELECTRIC																	
CREEP																	
SLOSH																	
WEIGHT																	
BURST II (TO FAILURE)																	
OVERSPEED																	
CONTAINMENT																	

COMPONENT AND LOGIC GROUP DEVELOPMENT TESTING STATUS

NOTES:
1. X - TEST TO BE PERFORMED.
2. A - THIS TEST WILL BE CONDUCTED IF ANALYSIS INDICATES NEED.
3. ◇ THIS TEST TO BE PERFORMED ON A LATER CONFIGURATION.
4. ■ TEST COMPLETED.
5. S - TESTED BY SIMILARITY.
6. + - THIS ITEM WILL BE CONSIDERED TYPICAL. ALL OTHER ITEMS WILL BE CONSIDERED TESTED BY SIMILARITY.

LOGIC GROUPS

A - 106, 107
B - 110, 122
C - 125, 127
D - 111, 208
E - 210, 204, 203, 208, 209, 214, 217, 220, 221, 222, 223, 290
F - 404, 409, 418, 490, 491, 419, 420, 421
G - 308, 307, 390, 391, 317, 323
H - 190, 308, 390, 391

EDP Sheet No. 120

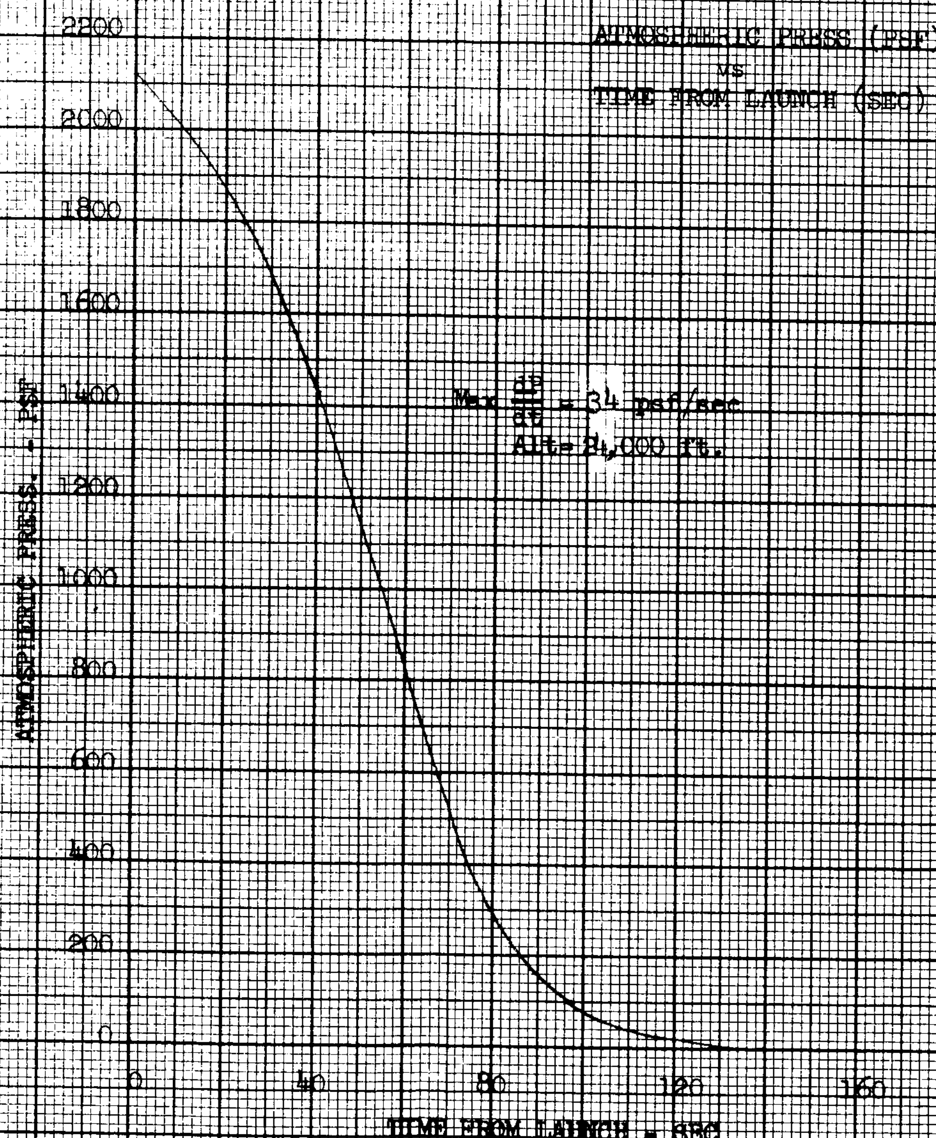

ATMOSPHERIC PRESS (PSF)
vs
TIME FROM LAUNCH (SEC)
Max $\frac{dp}{dt}$ = 34 psf/sec
Alt= 24,000 ft.
ATMOSPHERIC PRESS. - PSF
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
40
80
120
160
TIME FROM LAUNCH - SEC

Figure I

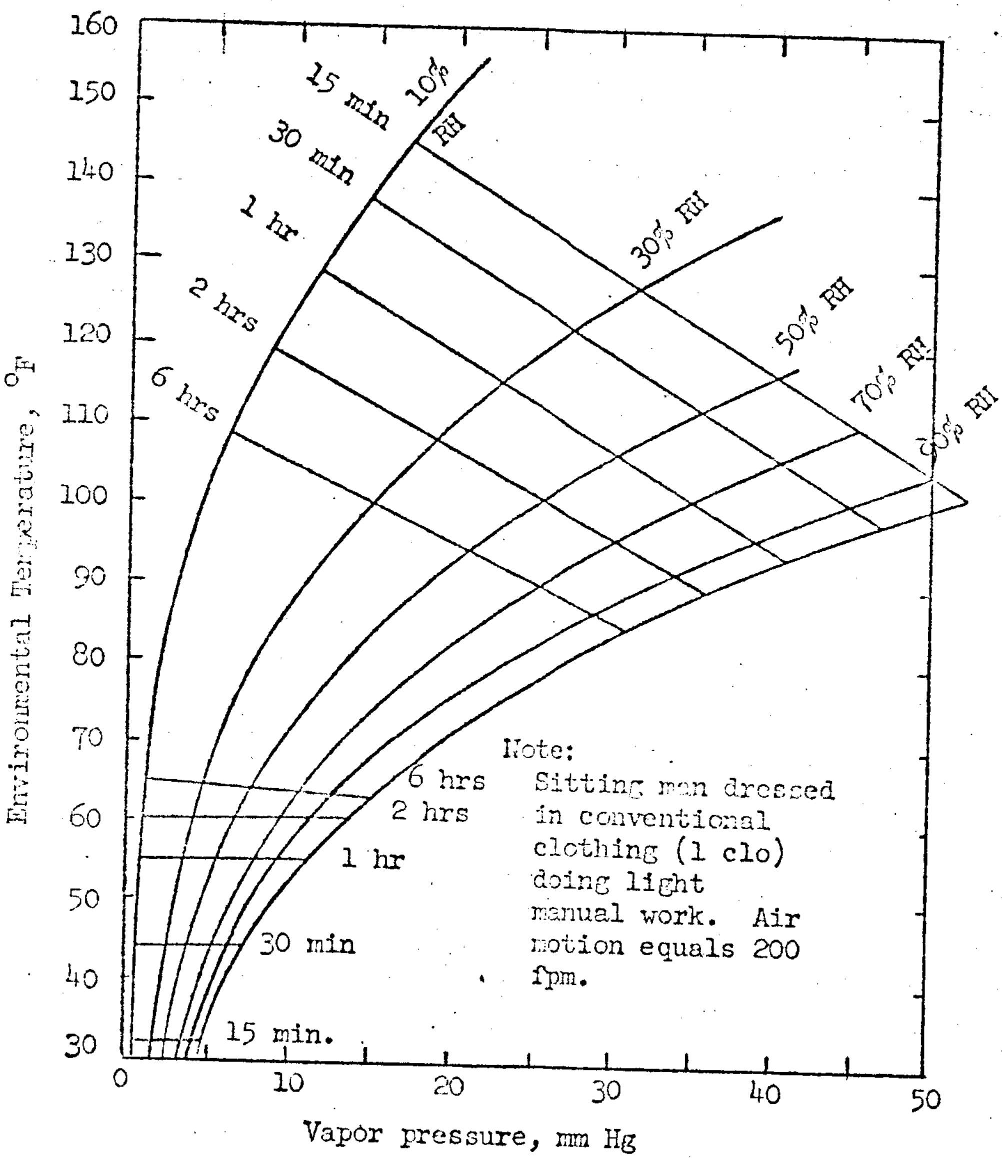
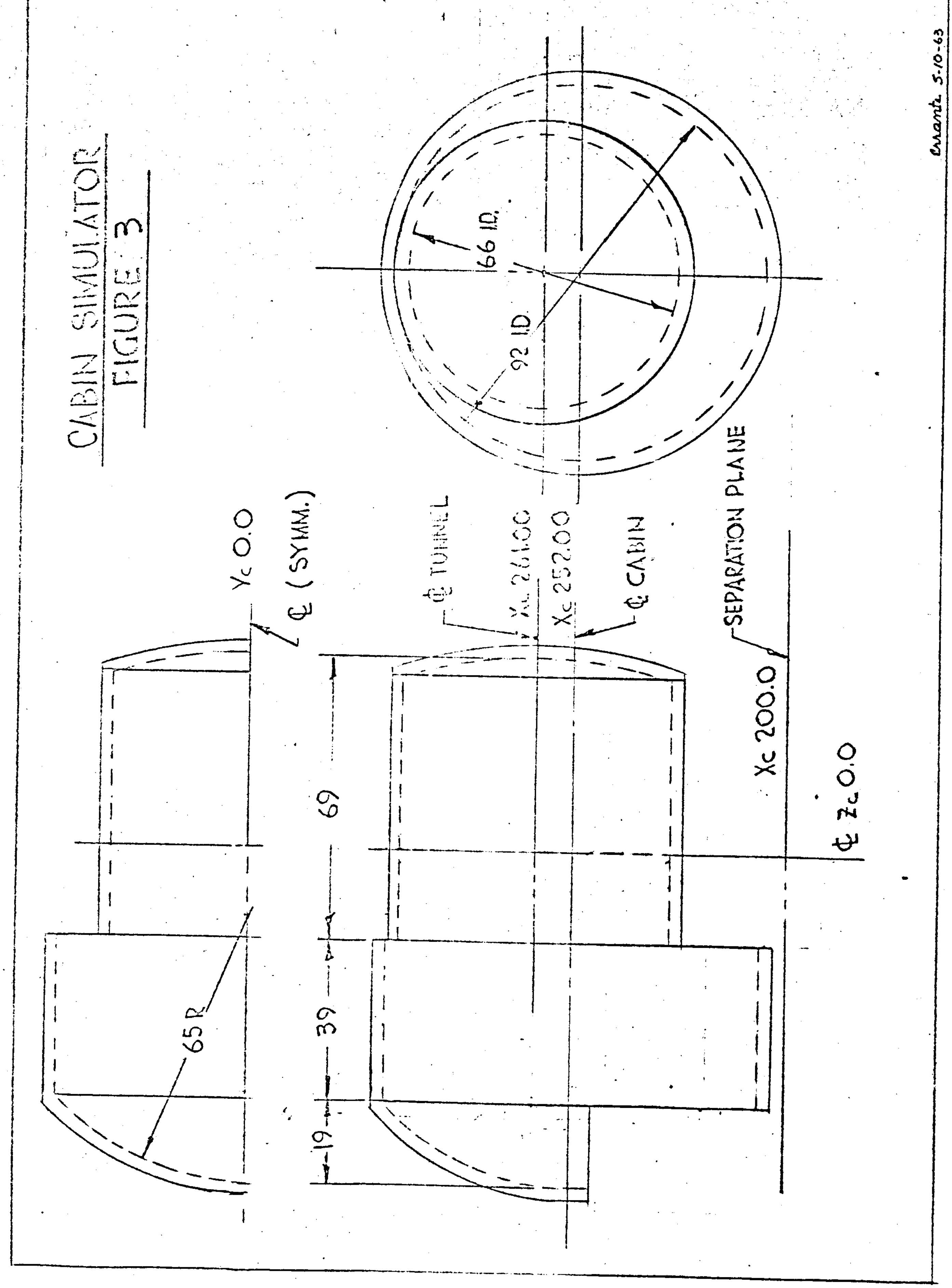


Figure 2 - Temperature and humidity emergency limit.


CABIN SIMULATOR
FIGURE 3
66 I.D.
92 I.D.
Yc 0.0
℄ (SYMM.)
℄ TUNNEL
Xc 261.00
Xc 252.00
℄ CABIN
SEPARATION PLANE
Xc 200.0
℄ Zc 0.0
69
39
19
65 R

Date: 1-31-66
Page: 123

HEAT CAPACITY OF SUIT FLOW
VS
HEAT CONVECTED TO CABIN
FOR A
70°F, 75°F & 80°F CABIN

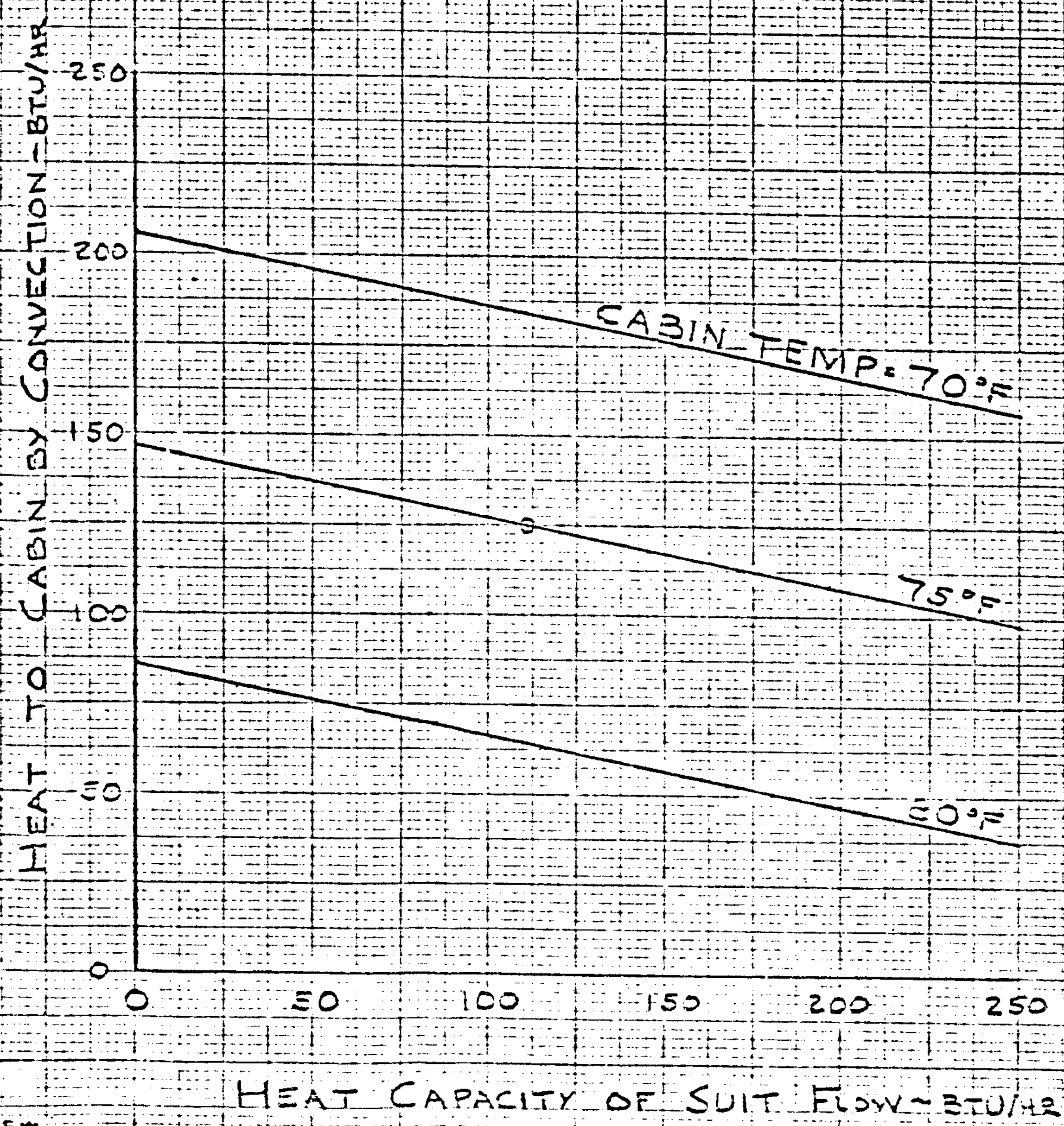
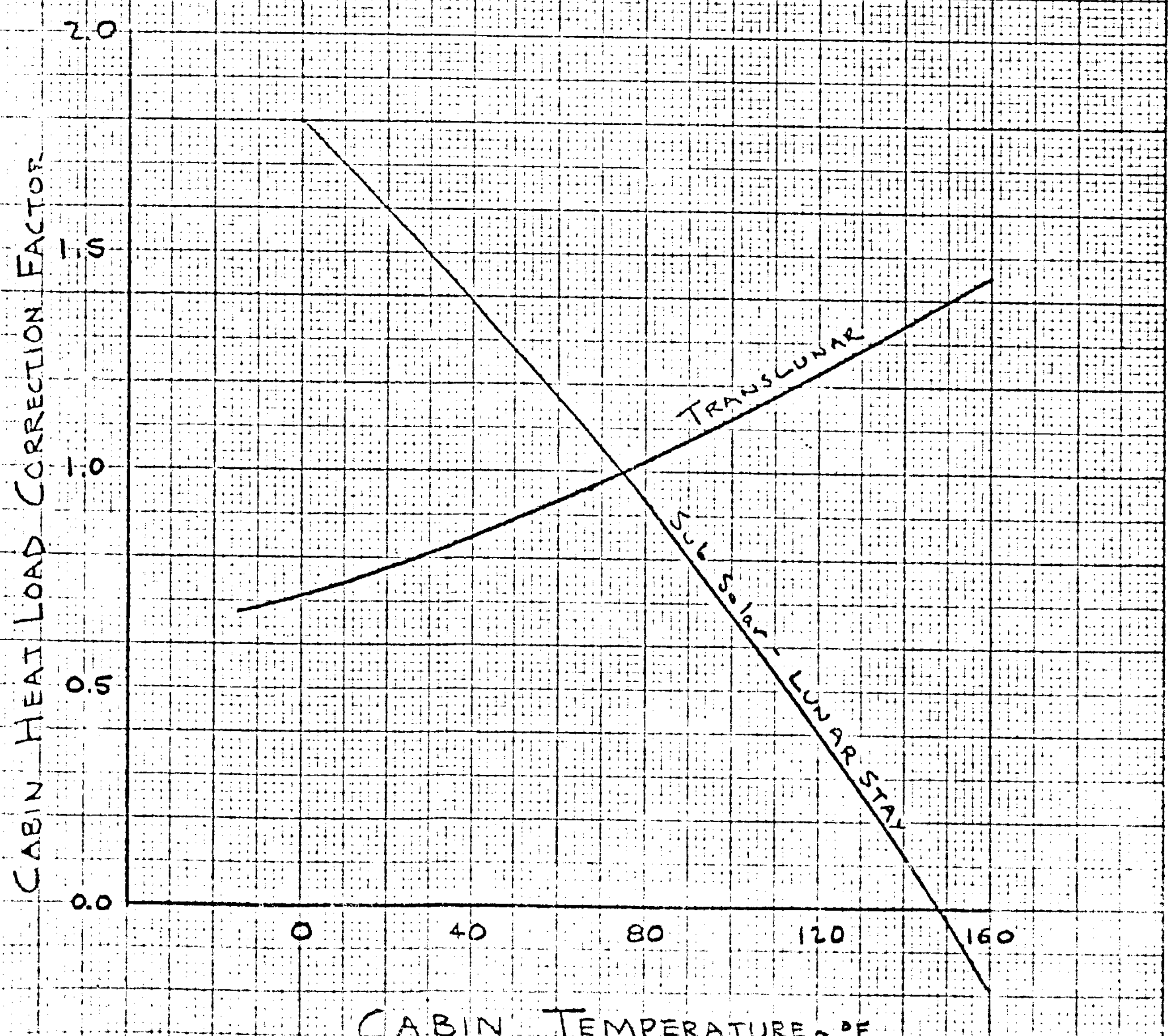


Fig 4

EDP Sheet No. 124

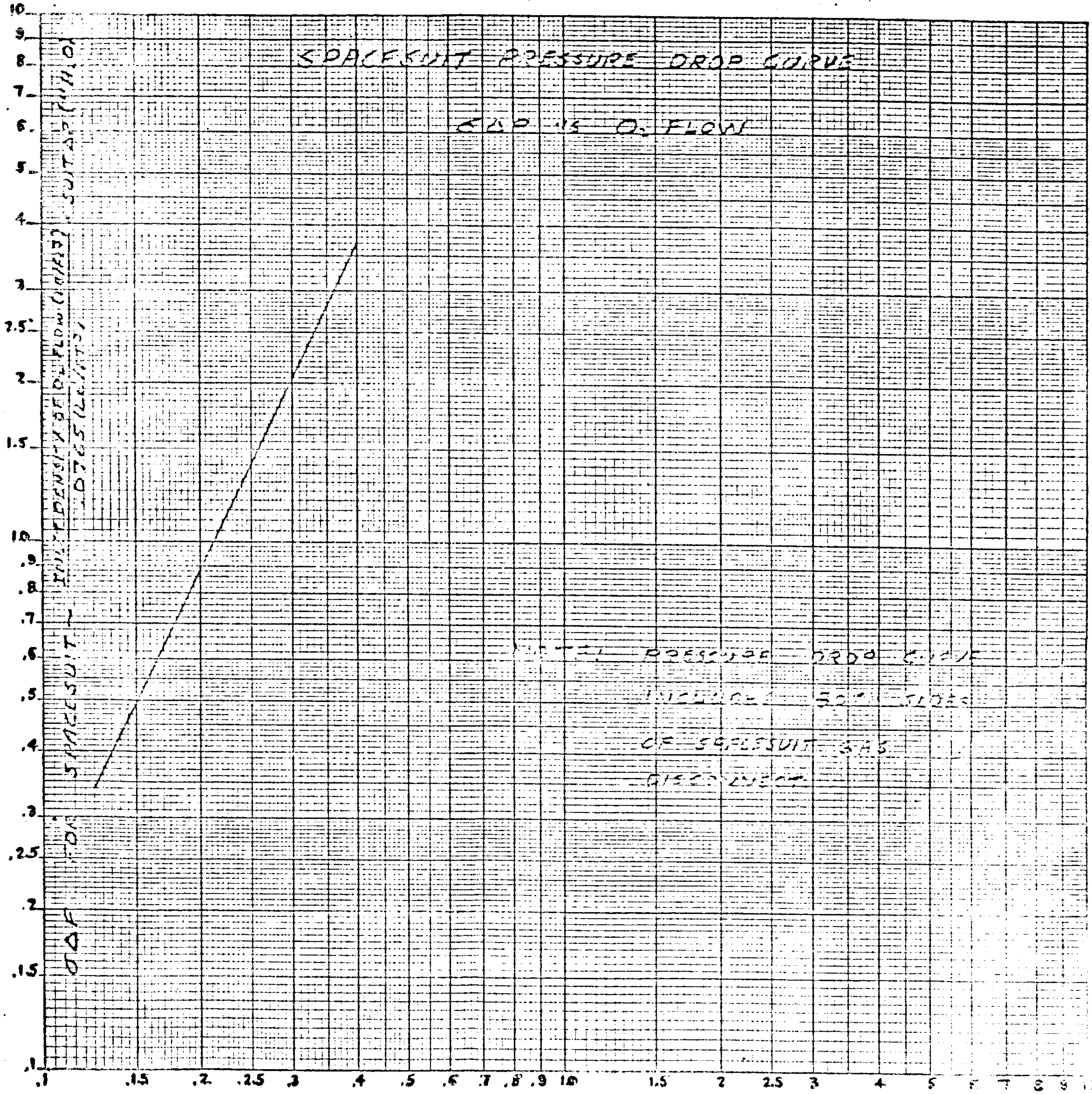
CABIN HEAT LOAD* CORRECTION FACTOR
VS
CABIN TEMPERATURE

* STRUCTURAL HEAT LOAD



LEM

Fig. 5



SPACESUIT OXYGEN FLOW ~ LB/MIN

Fig. 6

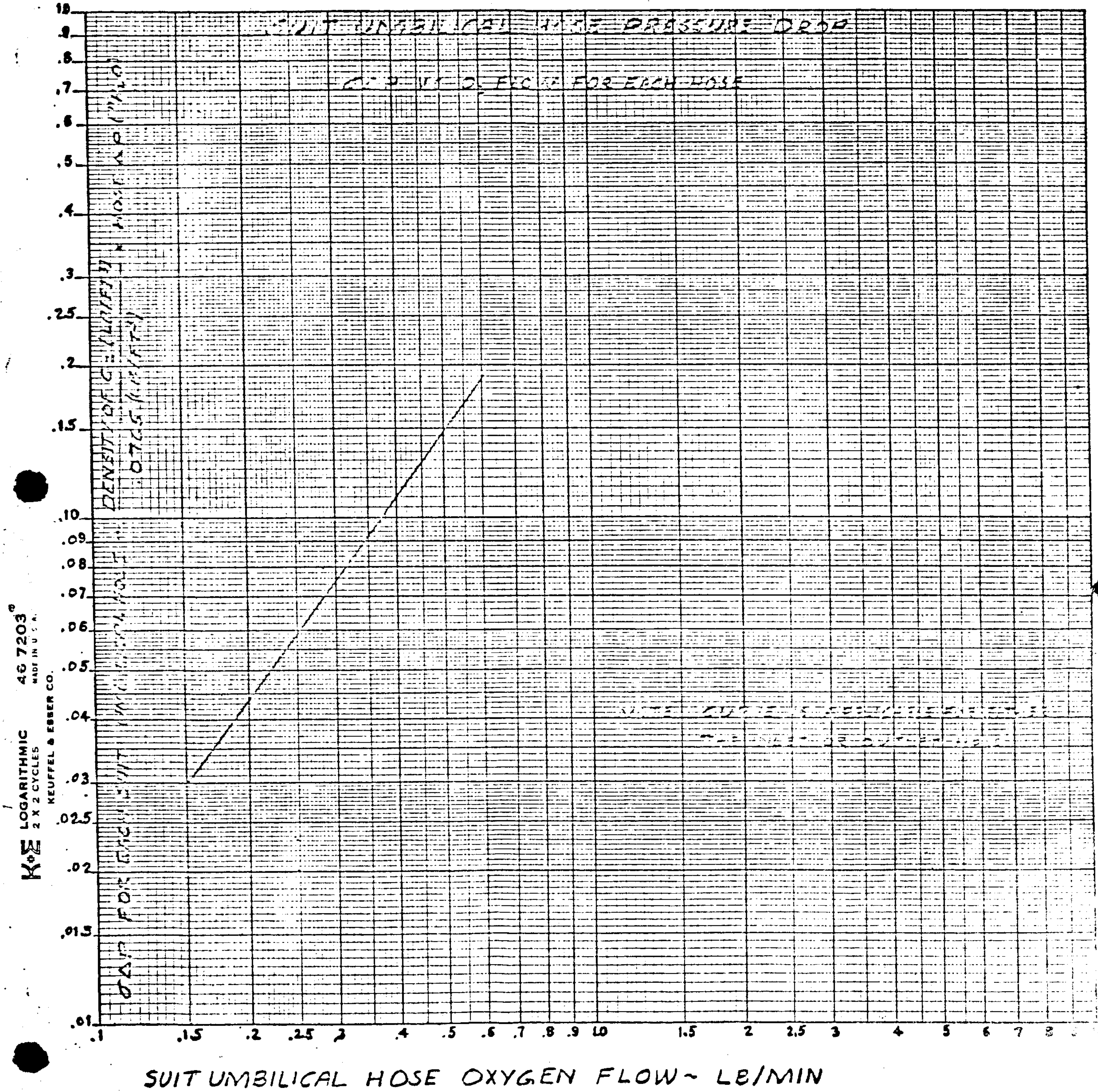

PRESSURE DROP
FOR EACH HOSE
K+E LOGARITHMIC 46 7203
2 X 2 CYCLES
KEUFFEL & ESSER CO.
MADE IN U.S.A.
1.0
.9
.8
.7
.6
.5
.4
.3
.25
.2
.15
.10
.09
.08
.07
.06
.05
.04
.03
.025
.02
.015
.01
.1
.15
.2
.25
.3
.4
.5
.6
.7
.8
.9
1.0
1.5
2
2.5
3
4
5
6
7
SUIT UMBILICAL HOSE OXYGEN FLOW ~ LB/MIN

Fig. 7